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PRESENT TENDENCIES IN THE PHILOSOPHY OF BIOLOGICAL EVOLUTION.

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I.

Man has been called the problem-solver. This is increasingly true, for as our social organization is becoming more and more complex, new problems are arising and demanding solution. Although most certainly man must be credited with the solution of many vexing problems, his interest far out-strips the limited number of difficulties which his ingenuity has actually been able to meet. The mere contemplation of the formidable array of problems of human as well as mechanical engineering, many of which have arisen in the last century, is bewildering. There is yet so much to be done, and each day brings so many new problems that we often despair of the future and assume that we live in an age the peculiar characteristic of which is its difficult problems. But let us not fall into the error of believing that all of our problems are of recent origin, for some of them, if not many of them, perplexed early man as well as the modern scientist. One such problem is that of the origin and development of life. Darwin, as the uninitiated believe, was not the first to speculate concerning life and its development. The Greeks[1] and even the ancient Egyptians[2] and Babylonians, and the Sumerians and Semites who preceded them, were concerned with this most difficult problem—one of the as yet unsolved problems of our age.

[1]G. J. Dudycha: "What Is Evolution?" *Scientific Monthly*, 29: 317–332, October, 1929.

[2]G. J. Dudycha: "Ideas of Origin Among the Ancient Egyptians and Babylonians," *Scientific Monthly*, 32: 263–269, March, 1931.

We can not here review that interesting history of the ideas concerning the development of life—a history which covers a period of nearly six thousand years. During this long period many careful thinkers grappled with the problem of how-did-things-come-to-be-what-they-are and each contributed, from his individual point of view and from his meager or intimate knowledge of the phenomena of nature, such ideas and such principles as he thought gave meaning to life. In spite of the fact that numerous solutions have been offered for the problem of development, none has satisfied all the searchers after truth. Yet, there is hope! New views are still being presented and new light is constantly being shed upon the perplexing problem. We are still grappling with the history of life!

II.

In this paper, we shall deal with four outstanding, contemporary ideas concerning biological evolution. The first of these is that of Mr. John Langdon-Davies which appeared as an article in *Harpers* under the title, "The Loves of Orchids."[3]

After a severe criticism of Darwinism, Mr. Langdon-Davies raises the following question for which he supplies the following answer: "How, then, are we to 'save the phenomena'? There is only one way and that is by limiting the power of 'blind chance' and assuming the dominance of 'mind' and memory in all these strange happenings; in believing, in short, that an animal has the organism and uses it in the way it does because it remembers from past experience, when, instead of being itself, it was its ancestors, that just that organism is useful, and just that way of using it is best."[4]

The question which immediately arises in our minds is, What is here meant by the terms "mind" and "memory" and how do they operate so as to promote development? Let us again examine our text and see if we can find an answer. Again I quote. "When the living being is faced with a given situation it behaves as it did when it last found itself in that situation. What happens when it meets a new situation? Either it dies because it can not think of anything to do or it makes some necessary alteration in its organism to meet the

[3]J. Langdon-Davies: "The Loves of Orchids," *Harpers*, 160: 374–381, February, 1930.

[4]J. Langdon-Davies: *loc. cit.*, p. 380.

new situation. Its offspring remember in their turn what to do and change their organism in the same way, and we have what we call an inherited variation, the product of mind and memory working out sensible solutions to the problems of life. . . . . And to memory must be added the ability to think for itself, that is, to vary and to act upon its thought so far as environment will permit."[5]

Now that we have the essential ideas of Mr. Langdon-Davies in mind, let us consider them critically. First, what does he mean by "memory?" This term is sometimes given two meanings, the one, biological and the other, psychological. From the point of view of biology, a modification which is made, perpetuated and inherited is said to be remembered. In this concept consciousness is not present. If this is what the writer of, "The Loves of Orchids" means, then we can raise no objection, but does he? From the psychological point of view, memory refers to a conscious process—the consciousness that a present experience is more or less intimately related to an experience in the past. Is this what Mr. Langdon-Davies means by memory? We may suspect that it is when we recall the statement: "Either it dies because it can not think of anything to do or it makes some necessary alteration in its organism to meet the new situation." The significant word here is "think." If thought is a conscious process, as we know it to be, and if orchids are capable of exercising thought, then their memory is also very likely conscious. If this is true, then perception would also seem to be a necessary characteristic of the orchids. In the end, it seems, we have been quite successful at personifying the orchids. Also we must note that memory in the psychological sense does not merely imply retention, as the biological use of the term does, but recall and recognition. It is not merely the retention of a modification made at some time in the past, but the ability on the part of that individual to consciously relate that modification or experience to the present. Is this what is done by the orchid, by the protozoan, and shall we be so bold as to say, by the star?

There is a second problem which we must consider. Mr. Langdon-Davies tells us that the orchid "makes some necessary alteration in its organism to meet the new situation" and that the "offspring remember" this change and thus make the

[5] *Ibid*, p. 381.

corresponding change in their organisms. Thus we have an "inherited variation." But again this raises a number of difficulties. Out of all the possible modifications, how is the particular initial modification effected? By taking thought! According to the language of the author of "The Loves of Orchids," the orchid must take cognizance of its problem—it perceives the problem, appreciates the need for its solution and "thinks" out a way of escape. The offspring "remember" the profound solution of the parent and ergo, we have an inherited modification in spite of the fact that not even man can add one cubit to his stature by taking thought. It is just this thought process that we would like to know more about, but unfortunately, we are told nothing about its nature.

The last problem to which we must call attention is the problem of mind. Although Mr. Langdon-Davies tells us that we shall probably have to change our notion of mind, he does not offer to define it for us and thus we are left with the unanswered question, What is mind? If the writer of our text, conceives mind as the force or drive which is responsible for the activity of the creative, developmental process, then another problem looms into view, namely, the problem of distinguishing mind as the go-of-events from mind as the end-result or emergent. From the way he uses the term mind we are led to believe that he is trying to use mind—the end-result, product or emergent—as the drive in all development. This does not seem possible for mind, as he uses it, is itself a resultant. Although there most certainly are formative forces, the term mind should be reserved to designate the end-product, the result, the fruition of the creative process. If the meaning and the use of the term mind were definitely designated, some of our difficulties in understanding this point of view of development would be eliminated.

We had anticipated that after understanding Mr. Langdon-Davies' point of view of development we would have the answer to his question, "How shall we save the phenomena?" But now that we have examined his ideas carefully and critically, we are disappointed. We expected an answer to our problem, but instead we discovered new problems. But let us continue our search for an answer to the problem of how-did-things-come-to-be-what-they-are. Since we have merely considered the first of our four points of view, let us turn to a careful consideration of the second.

III.

Dr. Austin H. Clark, who has labeled his point of view "Zoogenesis,"[6] begins with two assumptions: (1) only life begets life, (2) all living things begin their life as a single cell in which there is not any discernible trace of the adult form. Thus in order to discover the order in the living world, we begin, first, with the idea of the continuity of life from its origin down to the present, and second, with the idea of the common origin of all life in the primitive single cell. Thus all life must have come from this primitive cell by some process. What was the nature of this process? Dr. Clark tells us, "that from the primitive single cell there *simultaneously*[7] appeared through mutation as many different types of animals as were capable of successful existence."[8] And thus, "all of the major groups of animals were formed at the same time as the result of following different developmental paths from the primitive single cell."[9] In support of this contention, he draws his evidence from embryology. "The several major groups exhibit a great variety of conditions in the relation of their different balance in their various essential organs. In their embryonic stages the representatives of the various major groups show a close approximation to each other in the gastrula, but are wholly similar to each other only in the germ cell."[10] To this first phase—simultaneous appearance of all the phyla from the primitive cell by mutation—of his point of view, Dr. Clark gives the name "eogenesis."

Since "we are forced to the conclusion that all the major groups of animals at the very first held just about the same relation to each other that they do today," we must also assume *concurrent evolution*. Thus the ground is prepared through eogenesis, but the growth of the trees—the phyla—is known as evolution. We have, then, the introduction of a second term, that is, *evolution* which is not used to designate a single process, but the individual history of each type of life. Thus

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[6]A. H. Clark: *The New Evolution Zoogenesis*. Baltimore: Williams and Wilkins, 1930.

A. H. Clark: "Zoogenesis: the New Theory of Evolution," *Scientific American*, 143 (2): 104–107, August, 1930.

[7]Italics are mine.

[8]A. H. Clark: *The New Evolution Zoogenesis*, p. 220.

[9]*ibid*, p. 212.

[10]*ibid*, p. 216.

we have as many evolutions, all of which are running concurrently, as we have types of life.

Yet a third question presents itself: How do animals change their form? For this there are three things necessary: first, there must be the production of variants or mutants; second, these variant characters must be heritable; third, the mutants with their heritable characters must be capable of meeting the conditions under which they live to such an extent that their kind is perpetuated. Since specialization is a function of progressive subtraction, the more remote the particular manifestation of life is from the primitive type the less the possibility of producing extensive mutants which vary greatly from the parent type. Thus, "the primitive single cell, having within the potentiality for the production of all types of animals, might be assumed to be possessed of the ability to produce simultaneously mutants which would be widely different from each other, both by structural changes in the single cell and through development involving cell multiplication in various directions."[11]

We see, then, that the process which results in the simultaneous appearance of all types of life is known as eogenesis; the development of many animal forms from the single original type is known as evolution; and the process by which new forms appear is known as mutation. Life is not to be thought of as a single tree with its branches arising from a common trunk, but as a forest of trees each of which has its roots in the soil prepared by eogenesis.

Although the above description of this second point of view might be greatly elaborated, we have Dr. Clark's essential thesis. Let us, then, examine it more carefully. A number of questions arise in our minds. What does he mean by *simultaneous* appearance of all types of life? What are the conditions which were responsible for the simultaneous appearance? What was potential in the primitive cell? Let us return to the first question. What is meant by "simultaneous"? Are we to understand that all types of life appeared from the single cell at the same instant, or that all appeared at some time during pre-Cambrian times? Again we ask, Did all the types of life come from a single cell, or from primitive cells, or did some separate later from the gastrula? If we shall return to our text, we shall find the following statment: "The

[11] *ibid*, p. 220.

only possible conclusion is that there is not now, and there never has been at any time in the past, any linear relationship between the major groups of animals at any stage later than the gastrula."[12] This seems to indicate, as we also find in the figure on page 246, that some of the phyla had their origin in the gastrula, which is a later development from the primitive cell, and not directly in the primitive cell itself. Thus we find that our notion of what is meant by "simultaneous appearance" is vague.

The second question which we raised was concerning the nature of the conditions which gave rise to the simultaneous appearance of all the phyla. It is difficult for us to imagine how certain conditions, obtaining at this early time, could be responsible for the sudden appearance of numerous types differing widely, and then not continue to produce additional types. In other words, why did the whole thing occur once and for all and never again? It seems that Dr. Clark would have us believe that the original diversification of life was cataclysmic and not gradual as it seems to have been subsequently.

There is yet another objection which we must note. Paleontology, as Dr. Matthew[13] points out, does not warrant Dr. Clark's conclusion concerning concurrent development from the original appearance of all of the types of life. Although it is fairly evident that there are various independent lines of development, which have been more or less parallel, since Cambrian times, it does not follow that they were equally independent in pre-Cambrian times. We must admit that our knowledge of the history of life in pre-Cambrian times is very sketchy and incomplete, but what little is known does not seem to point in the direction of Dr. Clark's thesis. It is probable that the laws of nature, which we observe are operating now, operated then, and that all the types of life did not appear suddenly and miraculously.

We have examined *Zoogenesis* and have found that it too is wanting. We had hoped that we would find a solution to the problem of the development of life, but instead we are faced with more questions. We are not ready, however, to give up our quest. Let us turn to our third point of view.

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[12] *ibid*, p. 248.

[13] W. D. Matthew: "The Pattern of Evolution," *Scientific American*, 143: 192–196, September, 1930.

IV.

Professor H. J. Muller,[14] who in a recent article entitled "The Method of Evolution" discussed some of the results which he has obtained from his noteworthy experiments on the fruit-fly, *Drosophila*, makes a very interesting suggestion which may throw light upon our problem. He has found that by treating the fruit-fly, *Drosophila*, with X-rays a large variety of mutants, some of which have favorable and others unfavorable characteristics, may be produced. In addition to X-rays, he believes that radium rays, gamma rays and cosmic rays affect organisms in a similar way and thus produce variations. With this idea in mind he draws the following conclusion: "This being true, there being no evidence of a minimal or 'threshold' dosage, we are forced to conclude that the minute amounts of natural radiation present almost everywhere in nature—some of it of terrestial origin, derived from the radium and other radioactive substances in the earth, water and air, and a smaller part of it of cosmic origin, apparently derived from the diffuse and distant factories of matter—all this natural radiation *must* be producing some mutations in the living things on the earth. These mutations must be very scattered and very infrequent in proportion to the total non-mutated population, just because the amount of natural short-wave-length radiation is very small at any one place, but, considering the extent of the earth and the multiplicity of living things, the total number of mutations so produced per year must be very considerable. It can, therefore, scarcely be denied that in this factor we have found at least *one* of the natural causes of mutation, and hence of evolution."[15]

Recently attempts have been made to test this hypothesis that radiations of the earth cause mutations in genes. As the result of experiments, it has been found that fruit-flies, which were reared in a tunnel in the mountains where radiation was strong, produced more mutations than were produced in the laboratory where radiations were weak. We must note, however, that not only do radiations of the earth affect the rate of the appearance of mutations; but also that temperature, as has been pointed out by Professor Muller, determines their

[14]H. J. Muller: "The Method of Evolution," *Scientific Monthly*, 29: 481–505, December, 1929.

[15]H. J. Muller: *loc. cit.*, p. 496.

rate of appearance in much the same way that temperature speeds-up a chemical reaction. In view of this, Dr. Davenport says:

"Also, it seems probable that radiations are not the primary cause of gene mutations but that they accelerate processes that are initiated by the internal structure of the genes.

"That the essential nature of gene mutation is determined primarily by internal conditions is well shown by the experiments of Demerec. . . The gene has internal capacity for mutation just as an alarm clock has an internal mechanism for ringing a bell at a particular time. Gene mutation can arise from the very mechanism of the gene."[16]

Apparently, then, according to Davenport, the real cause of mutation is in the very nature of the gene and X-rays or the related waves of shorter wave-length, as gamma and cosmic rays, are merely conditions which hasten the process.

No doubt, Muller would refute this objection by pointing out that the powerful rays which affect the gene cause changes there-in which lead to its reorganization. He says: "For the electron, shot out like a bullet (except far faster), tears its path through thousands of atoms that happen to lie in its way, leaving in its wake a trail of havoc before it is finally stopped. In this process, many of the atoms through which the electron tears have one or more of their own electrons torn out or dislodged from their proper places; this change in the structure of the atoms often causes them to undergo new chemical unions or disunions that in turn alter the composition of the molecules in which the atoms lay. If a gene is a molecule, then, with properties depending upon its chemical composition, it can be shot and altered by the electrons resulting from the absorption of X-rays or rays of shorter wave-length."[17]

Here, then, we find in Muller's conception of cosmic energy as the cause of the process of development *one* of the possible methods of development. Since his conclusions are based upon extensive laboratory studies rather than upon pure speculation, and since they do seem to be so highly suggestive, we are greatly inclined to believe that perhaps we have found here something significant, and that some light is being shed upon our difficult problem.

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[16]C. B. Davenport: "Light Thrown by Genetics on Evolution and Development," *Scientific Monthly*, 30: 307–314, April, 1930.

[17]H. J. Muller: *loc. cit.*, p. 491.

V.

The last point of view concerning the possible methods of development which we are to consider is that of a cytologist. Dr. Philip R. White in his recent article, "A Disease and Evolution,"[18] points out that hybridization is most certainly one of the methods of evolution. Due to the extensive losses which have been sustained on the banana plantations which have been caused by the ravages of the "Panama disease," Dr. White studied Gros Michel, our edible banana, with the idea that immunity might be produced by hybridization. If one of the parents is immune, he reasoned, why could immunity not be produced by breeding the parent again? Thus the first problem was to discover the parents of Gros Michel. After a careful examination of the nuclei of the cells of the banana, he found that each contains thirty-two chromosomes which, of course, should give at syndesis, if the parentage has been proper, sixteen pairs. This, however, did not happen for only twelve pairs were observed and eight extras which were scattered and unattached. Thus when the daughter cells were formed these eight extras were often unevenly distributed. Since this is true, the question is, Who are the possible parents of Gros Michel?

Because of what happens at syndesis in the banana, it seems quite apparent that it received twelve chromosomes from the one parent and twenty from the other, which thus gave rise to the twelve pairs and eight extras. Since each parent, except in unusual cases, contributes one-half of its chromosomes to its off-spring, one of the parents of the banana must have had twenty-four chromosomes and the other forty, unless, for some unknown reason, one of the parents contributed all of its chromosomes. With this assumption, Dr. White proceeded to look for the possible parents of Gros Michel and as the result of an extensive search found 38 individuals with twenty-four chromosomes, two with twenty, one with twelve and a single forty. In addition to these possible parents of the banana, Dr. White studied 108 other varieties all of which were discarded. Although he did not find definitely which of the possible parents of Gros Michel were the actual parents, he did make one very significant observation, that is, that we

[18]P. R. White: "A Disease and Evolution," *Scientific Monthly*, 31: 306–318, October, 1930.

have here in the banana a polyploid series the basic number of which is eight and that all of the 150 varieties studied, whose chromosomes range from twelve to forty-eight in number, may be accounted for by some process of combination and hybridization which began with the original banana with eight chromosomes.

Thus we have here another "method" of evolution presented. "In a recent issue of this journal," says Dr. White,[19] "there appeared a paper by Professor H. J. Muller entitled 'The Method of Evolution.' I should prefer that he had entitled it 'A Method of Evolution,' for though the evidence of the existence of mutations is unquestionable and the evidence for the activity of cosmic and earth rays in producing these mutations grows from day to day so that I should certainly not concur with Professor Jeffrey in ridiculing this method, I nevertheless feel that the evidence for concomitant evolution by hybridization is even better established, and that, while perhaps it is not so fundamental in scope as is the 'ray' evolution, it has played a much more obvious and far-reaching role than has the former. This polyploid genealogy is not an isolated example but is typical of whole family groups and also occurs (perhaps of a different origin?) in Professor Muller's own fruit-flies."

Here, then, we have another highly suggestive point of view, based upon extensive experimentation and research, which can not be readily refuted. Thus we see that Dr. White in emphasizing that the changing pattern of life is due to the changing pattern within the cells, which results from particular kinds of combinations, has shed more light upon our vexing problem.

VI.

Now that we have considered four contemporary points of view concerning biological evolution, we come to grips with the problem of development itself. Mr. Langdon-Davies, we found, posited mind and memory as the two important factors responsible for the progressive development in the history of life; but he failed to tell us how these two factors operated, let alone what they are. To merely say that a plant or an animal in the presence of a given difficult situation thinks out a way of

[19] P. R. White: *loc. cit.*, p. 318.

escape and that its off-spring remember its solution tells us nothing. We do not know why the organism thinks, how it thinks or for what reason it remembers. We merely have two words "mind" and "memory"—magic words—which have worked a potent charm and thus we have all the various forms of life. This view of things is certainly not satisfying, nor is it particularly new. Mind has too long been invoked as a mysterious *cause* of things.

Zoogenesis, we have also found, is but little better than the first point of view which we considered. By some mysterious means all the types of life burst forth simultaneously from the primitive single cell. There certainly is no conclusive evidence that such a thing ever did occur, nor can we comprehend how it could have been the case since that has quite apparently not been the method of nature during historic times. Again we find in Zoogenesis the idea of the potentiality of all things in the primitive cell. "The single cell has inherent in itself the potentiality for development, through selective and progressive reduction in various directions and in various ways, into every form of life which at any time may be capable of existence and of self-perpetuation under the conditions obtaining at that time.

"All animal types are therefore to be regarded, in their relation to cosmic evolution, simply as varied and varying manifestations of the inherent potentialities of the fundamental substance protoplasm. Such a concept contemplates the animal world as in reality but a single unit finding its expression in an infinity of equations all of which, no matter how complicated they may seem, reduce themselves to the same fundamental term."[20]

This by no means is a new idea for St. Augustine expressed essentially the same idea centuries ago. Putting Augustine's idea in modern terms: "In the beginning God made" the first single cell—germ or seed—in which all things that are found in the world today were implicit, and by a process, governed by natural laws with which the Creator endowed this first piece of matter, have become and are becoming explicit. The first cell was the potential universe with all things that are found therein. But Augustine's idea is no longer tenable; it is not adequate as a philosophy of development.

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[20]A. H. Clark: *loc. cit.*, p. 216.

Hence Zoogenesis is also inadequate. It may appear to be serviceable when one is dealing with the development of life, although we have found difficulties even here; but it is wholly inadeqate when one deals with the whole of development of which biological evolution is merely one phase. Hence Zoogenesis has but little to offer us for a philosophy of development.

The last two methods of evolution which we considered—that of cosmic radiation as the cause of development, and hybridization—are the most significant for the philosophy of evolution. In order to have a process we must have a drive of some kind which is the go-of-events. This drive has been variously termed by philosophers—vital urge, *elan vital*, nisus, etc. Perhaps we might be so bold as to include cosmic radiation, but this is still somewhat hazardous. Although we may quite readily see that cosmic rays are at least one of the causes of biological evolution, it is not so easy to see the relationship between this short-wave-length radiation and other more extensive aspects of the development of the universe. There may, however, be a significant relationship which only future study will reveal. On the other hand, hybridization is directly in accord with one of the outstanding present-day philosophical concepts of development—namely, *emergent evolution*. An hybrid is an emergent. Professor Nabours[21] says:

"It has long been known, and is every day becoming more obvious, that sexually reproducing organisms, including man, are generally heterogeneous (we now know not exclusively heterozygous) for a wide range of genes. It has also been ascertained that each discrete characteristic is due to the interactions of several or many different genes, whether in heterzygous or homozygous doses, or distributed over one or more pairs of chromosomes. This fact having been well established and universally acceded to by geneticists, it may, with good reason, be suggested that such characteristics are not merely the additive sums, mosaics, or resultant combinations of the activities of the respective genes, but they are emergences in the same sense that ethyl alcohol and ether are emergences of the respective syntheses of the elements hydrogen, carbon and oxygen."

Thus we have here an idea concerning the method of development which is not only serviceable in biology, but one which

[21]R. K. Nabours: "Hybrid Emergence," *Eugenical News*, 15, July, 1930.

is also in accord with a more general process which includes many other aspects of the universe than merely life.

When we are dealing with biological development, we can not avoid turning our attention to the broader aspects of development, to cosmic evolution. As the careful thinker directs his attention away from his immediate surroundings to the infinite spaces, and contemplates the nature of the universe with its gigantic, heavenly bodies moving at incredible speeds, and with its vast interstellar spaces, its detailed organization and perfection in operation, he asks, "What is man?" But then, courage rises for not only that brightly beaming star and yonder planet, but man and even the lone daisy in the grass, all are a part of this vast and intricate system. Truly it is a *universe!* This being true, there must be some cosmic process—a single process—which is not only responsible for the suns and our earth, but also for the atom, the molecule, the crystal, the organism and for society with all its ramifications. The most apparent difficulty in the history of thought concerning evolution is that too many thinkers—profound thinkers—are interested in but a limited portion of the universe—life. They have propounded many theories of biological evolution, which often appear to be adequate concerning the development of life, but which can not be stretched to fit the universe. No theory of biological development is adequate unless it is in accord with the more general aspects of cosmic evolution.

THE ALIMENTARY CANAL OF MERACANTHA CONTRACTA BEAUV. (TENEBRIONIDÆ).*

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Introduction.

The Tenebrionid beetle, *Meracantha contracta* Beauv., is a medium sized (11-13 mm.), ovate and strongly convex species. It is wingless and especially distinguished by having the head received in the thorax nearly to the eyes. It occurs east of the Mississippi River and is very abundant in the oak and maple forests of the northern part of Ohio.

The problem of making an anatomical study of the alimentary canal of this species was suggested because of the availability of specimens and their interesting bark eating habits. The specimens used for this study were collected at Put-in-Bay, Ohio, from the trees found on the northern border of South Bass Island.

The process of preparation was as follows: The specimens were chloroformed, the elytra cut off and then the abdomens of some slit open dorsally, of others ventrally, before being fixed in Carl's fluid and preserved in 80% alcohol.

Upon dissection of the specimens it was discovered that in many cases an improvement could have been secured by a more extensive opening of the body, especially through the thorax and head. This would have allowed a much quicker penetration of the tissue of the anterior end of the mid-gut and the fore-gut as the heavy chitin surrounding this region slowed down the action of the fixative thus causing some tissue disintegration before complete permeation was reached. The fore-gut especially was very inaccessible, as it was found to be confined to the head and of necessity therefore, extremely short.

Due to the heavy intima of chitin in the fore- and hind-guts, it was found necessary in sectioning to pay particular attention to keeping the edge of the microtome knife sharp as there was a constant tendency for these sections to crush and tear. Most

*Contribution from the Department of Zoology and Entomology, Ohio State University, No. 106.

of the sections were cut 8 microns in thickness and gave good results in staining.

The ordinary double staining process with Delafield's Hematoxylin and Eosin was used in the preparation of slides.

The drawings were made with the aid of a camera lucida.

The author desires to express his sincere appreciation for the helpful suggestions and criticisms of Doctor C. H. Kennedy, under whose guidance and direction this work was undertaken.

General Description.

Strictly speaking the alimentary canal is a rather simple tube extending from one end of the insect to the other. In the case of the beetle under discussion, which is a phytophagus or plant eater, it is of medium length extending in a nearly median line (Figs. 1-2) from the mouth parts back to the beginning of the abdomen where it curves slightly to the right down as far as the third segment, where it curves to the left and comes up to the first segment close to the edge of the body cavity and near the dorsal surface. It is then angulated and again approaches the median line just anterior to the first segment and then passing over itself in the second and third abdominal segments. It is thus nearly half again as long as the entire body.

Meracantha contracta, as is generally true of all insects, has three primary divisions of the alimentary canal present (Fig. 3); the stomodium or fore-gut, the mesenteron or mid-gut and the proctodeum or hind-gut.

The conditions concerning the attachments of the canal in the body are the same as in all insects: the fore-gut and hind-gut are invaginations of the ectoderm and therefore the body wall is, of necessity, continuous with the alimentary canal at both extremities. It is also supported by tracheæ along its entire length, as these support the gonads and fat-body, which in turn form a supporting sheath about the canal. Also there are certain suspensory muscles attached to the dorsal wall.

In origin, the fore-gut and hind-gut, as mentioned in the preceding paragraph, arise as invaginations of the body wall, and thus are ectodermal in origin. The mesenteron, however, has an altogether different history as it is formed by the proliferation of rings of endodermal cells, one around the inner end

of the fore-gut and the other around the inner end of the hind-gut. The endodermal cells form the digestive epithelium and all muscles, tracheæ and connective tissue concerned with the canal are of mesodermal origin.

Thus two important features of the canal will be observed; first, that the fore-gut and hind-gut being ectodermal in origin, resemble the body wall in structure, and second, that the mid-gut being mesodermal in origin, presents a marked difference, histologically, from either the fore-gut or hind-gut.

The gross parts of the canal of *Meracantha contracta*, can be listed as follows:

1. The mouth, the part opening to the exterior, located in the head and concerned with the mouth parts.
2. The pharynx, the region just distal to the mouth.
3. The oesophagus, the first and most simple part of the throat tube.
4. (No crop is evident because of the extreme shortness of the entire fore-gut, which extends only the distance through the head.)
5. The gizzard or proventriculus, the lower end of the oesophagus having a much thickened chitinous intima, thrown into many folds and surrounded by prominent circular muscles.
6. The oesophageal valve (cardiac valve); this is situated at the union of the fore-gut and mid-gut and acts as a valve below the gizzard, preventing regurgitation.
7. The stomach or mid-gut; this is the digestive part of the canal.
8. The pyloric valve; this is located at the union of the mid-gut and hind-gut.
9. The Malpighian tubules; these are six in number and are attached to the canal just posterior to the pyloric valve.
10. The hind-gut; this is the third primary division of the canal and is further subdivided into:
    - A. The small intestine or ileum, the small angulated part of the hind-gut posterior to the pyloric valve.
    - B. The large intestine or colon, the larger and somewhat thinner walled part of the hind-gut posterior to the ileum.
    - C. The rectum, a short funnel-shaped organ, connecting the colon and the exterior of the body.
    - D. The anus, the aperture connecting the rectum and the exterior of the body.

Each of these divisions will be described under the subject, "The Histology of the Canal."

The Histology of the Structure of the Alimentary Canal.

THE FORE-GUT OR STOMODEUM.

In *Meracantha contracta* this portion of the canal is confined entirely to the region of the head (Fig. 4), the union with the mid-gut taking place at the posterior opening in the head, which is slightly larger than the anterior end of the mid-gut. By actual measurement the fore-gut only averages two millimeters in length.

A longitudinal section through the head discloses that there is a definite adaptation to the bark-eating habit. Below the labrum or upper lip, which is slightly flexible, a pair of strong-toothed mandibles extend well back into the head, where powerful muscles operating

them are attached to the posterior walls. The mandibles work from side to side and each possesses at its posterior end, on the inner surface, a heavily chitinized plate known as a molar or crushing surface. Anterior to these plates are areas of thinner chitin, and from the floor of the mouth, slightly in front of the plates arises a hypo-pharynx or tongue-like structure which is connected with the posterior end of the labrum or lower lip. The posterior part of the mouth cavity is large and narrows down where it joins the anterior end of the fore-gut. (Fig. 4).

The pharynx extends from the mouth cavity to about where the tube is encircled by the large and prominent brain ganglia. The intima of the pharynx as well as that of the rest of the fore-gut, is armed with small backward directed spines, arising from small punctures or invaginations in the intima.

The oesophagus is very short and widens out considerably in a funnel shape before joining the mid-gut. The lower portion of the oesophagus has a prominent thickening of the chitinous intima which is much ridged in nature. This portion is known as the proventriculus or gizzard, (Fig. 6). No evidence of a crop is seen due to the extreme shortness of the fore-gut and probably little or no digestive action occurs while the food is passing through the fore-gut. No evidences of salivary glands were observed. Histologically, as a rule, the following layers, from within outwards, can be recognized. First, the intima or intermost lining, which takes the form of a chitinous layer, directly continuous with the body wall. Second, the epithelial layer, continuous with the hypodermis and chitogenous in function. Third, the basement membrane bounding the outer surface of the epithelium. Fourth, the longitudinal muscles. Fifth, the circular muscles. Sixth, occasionally the peritoneal membrane, a structureless connective tissue composed of very thin cells and difficult of detection.

Examination of a cross section through the fore-gut of *Meracantha contracta*, (Fig. 5) shows a well-developed intima consisting of a thick layer of chitin, armed with spines, the primary cuticula. This is backed by a variable region of chitin, the secondary cuticula. Next to the intima occur the rather large cuboidal epithelial cells. These vary somewhat in size but all contain large oval nuclei densely filled with coarse deep-staining chromatin granules.

The basement membrane is not clearly differentiated, but this is probably due to the action of the fixative. The longitudinal muscles occur within the circular muscles, lying in strands at irregular intervals. They continue throughout the fore-gut and pass on into the mid-gut.

The longitudinal muscles are continuous with the mid-gut and divide into several strands just before reaching the point of extension into the mid-gut. Some of these continue down into the folds of the valves while the rest pass between the circular fibers and cut abruptly across to the surface of the mid-gut where they continue throughout its extremity. (Fig. 6).

The circular muscles are very strongly developed, forming a continuous layer over three times the width of the epithelial tissue. They are clearly striated, with many nuclei present. They appear to have

developed in accordance with the effort required to force the bark particles eaten, down into the proventriculus.

The peritoneal membrane, if present, is not capable of detection.

THE UNION OF THE FORE-GUT AND MID-GUT.

At the point of union between the fore-gut and the mid-gut, a structure is present which is known as the oesophageal or cardiac valve. It is formed by a fold of the fore-gut extending down into the mid-gut. This then becomes reflected upon itself and passes forward to unite with the wall of the mid-gut. (Fig. 6).

The histological structure of the valve, discloses that the intima disappears at the end of the fore-gut, where there is a well-marked change in the character of the epithelium. These epithelial cells, in the fold, gradually change from a cuboidal shape into narrower and more elongate cells with their nuclei at the tips, thus they appear at the periphery of the curve in the fold.

Where the intima ceases, the epithelium has assumed the characteristic elongated type of the mid-gut, although there is a marked shortening in a few cells just preceding, due to the abrupt curve and impingement against the circular muscles.

A well-marked ring of circular muscles appears within the interior of the fold, which acts as a sphinctor, allowing the valve to be closed.

The longitudinal muscles are represented in the valve by only a few scattered strands extending down from the fore-gut.

The valve appears from a ventral view, as a number of flaps or folds, which when drawn together by the circular muscles, in much the same manner as a meal sack, fit together in such a way as to completely close the orifice and prevent any regurgitation of food. (Fig. 7).

THE MID-GUT OR MESENTERON.

This portion of the alimentary canal in *Meracantha* extends from the posterior part of the head to the third abdominal segment where it curves to the left and up to the first segment. (Fig. 3). Its great size in comparison with the rest of the tract is very striking. In addition, the ringed or segmented appearance of the gut is noticeable. This condition is due to the position of the gut circular muscles which are gathered together in bundles at intervals, and cause constrictions in the surface, that appear as rings about the gut.

The longitudinal muscles continue from the fore-gut down the mid-gut, crossing over the union of the two guts in distinctive bundles that give the anterior end of the mid-gut a constricted appearance at intervals. (Fig. 8). These constrictions are at right angles to the circular constrictions. The fibers then diverge and course along the mid-gut crossing the circular muscles at approximately right angles. Thus the whole surface presents a plaid-like appearance. The muscle fibers apparently do not inter-branch to any great extent, but are densely interwoven by very small tracheoles which run throughout the whole surface in very irregular fashion. (Fig. 9). Scattered at frequent intervals between the so-called bundles of circular muscles are isolated circular muscles.

The layers of the wall of the mid-gut are, from the inside out, as follows:

First, the digestive epithelium of endodermal cells.
Second, the basement membrane.
Third, the circular muscles.
Fourth, the longitudinal muscles.
Fifth, the peritoneal membrane which is not discernible in the slides prepared in this study.

The limits of the mid-gut are marked anteriorly by the oesophageal valve and posteriorly by the Malpighian tubules. Examination of a cross section through the mid-gut (Fig. 10) shows the epithelium to be composed of columnar cells, which vary considerably in length, size and shape, probably due to the physiological condition they happen to be in at the time. The majority of the cells however, are long and narrow and contain large median and ovate nuclei densely filled with coarse chromatin granules. Toward the outer margin of the cells, the nuclei gradually fade out. Scattered irregularly along at the bases of the cells are replacement cells pushing up from the nidi or nests of new cells. These cells are somewhat triangular in shape and wedged in between two of the larger cells, which, gorged with digestive secretions, burst into the lumen of the gut. Secretion is thus holocrine as the ruptured ends of the cells indicate. A striated border if present is obliterated by the broken and ruptured ends of the cells, as the insects were fixed at a time when the mid-gut was gorged with food and the process of digestion active.

A peritrophic membrane is present in the lumen, which protects the delicate epithelial tissue from the action of the coarse bark particles. This is probably secreted by the epithelial cells in general as there is no evidence of any specialized cells at the extreme fore end of the gut as found in some insects. In fact the membrane does not make its appearance until some distance back of the anterior end.

The basement membrane is present at certain portions of the cross section and probably would be evident throughout, if the action of the fixative had been quick enough.

Both circular and longitudinal muscles are striated, with numerous nuclei present, and their respective relation to each other in regard to position is the reverse from that found in the fore-gut, namely, the longitudinals being exterior to the circulars. The two layers interchange positions at the oesophageal valve, where the fibers interlace as previously described. (Fig. 6).

The connective tissue containing the muscles and surrounding the exterior of the canal is plainly evident.

No evidence was obtained of any differentiation between digestive and absorptive cells, probably they possess a double function which is characteristic throughout the mid-gut. The digestive epithelium terminates abruptly where the Malpighian tubules enter the canal, being followed immediately by the epithelium of the intestine or hind-gut.

THE UNION OF THE MID-GUT AND HIND-GUT.

THE PYLORIC VALVE.

In *Meracantha contracta* there is a definite pyloric valve which however, probably does not function in closing the gut as the fecal matter enclosed within the peritrophic membrane keeps the region of the valve widely distended.

In structure the form of the valve is very similar to the oesophageal valve, although there is not the gradual change in cell structure, (Fig. 11). Enclosed within the fold of cells is a definite group of circular muscles, with a few scattered strands of longitudinal muscles. The intima of the hind-gut where the valve commences, makes a gradual curve into the lumen for a short distance, then a sharp curve folding back upon itself before extending back into the gut, the epithelial cells abruptly shortening. Thus the portion of the wall called the valve is very little thicker than the wall at any other point. There is thus no impediment offered as the fecal matter is forced out of the fore-gut into the hind-gut.

THE HIND-GUT.

This is called the proctodeum and includes all of the intestine from the stomach or mid-gut to the anus.

Histologically, the layers of the wall of the hind-gut are, from within outwards, as follows:

First, the intima.
Second, the epithelium.
Third, the basement membrane.
Fourth, the inner circular muscles.
Fifth, the longitudinal muscle strands.

Sometimes there is present in some insects a layer of outer circular muscles and also a "peritoneal membrane" of connective tissue cells. These last two are lacking in *Meracantha contracta*.

The intima or chitinous lining is secreted by the epithelium which is invaginated body wall and has the same general characteristics as the hypodermis.

The epithelium is identical with the hypodermis of the body wall and is for the most part composed of cuboidal-shaped cells.

The basement membrane is indistinct throughout the hind-gut.

The inner circular muscles are a distinctive layer.

The longitudinal muscles are present and grouped for the most part into large bands.

Three well-marked regions are recognizable in the hind-gut: the small intestine or ileum, the large intestine or colon, and the rectum, (Fig. 3). These will be discussed in order.

THE ILEUM.

This region comprises about one-third of the total length of the hind-gut and is rather convoluted in the region of the first abdominal segment. It enlarges into the division called the colon at the point where the Malpighian tubules become attached to the surface of the gut.

The primary intima of this region is rather thin but the secondary intima is quite thick. The epithelium is composed of cuboidal-shaped cells and thrown into folds, six seeming to be the average. The cells are distinct in the anterior part of the gut, but tend to become less distinct posteriorly. The nuclei are large and prominent.

The circular muscles are well developed throughout the region. The longitudinal muscles lying outside of the circulars, are scattered at irregular intervals over the ileum.

The basement membrane is indistinct, both throughout the ileum and the colon as well.

THE COLON.

There is no abrupt transition, between this region and the one preceding as the epithelium changes gradually in appearance. The primary intima becomes somewhat thicker, with the secondary still very evident.

However, a new set of longitudinal muscles makes its appearance, outside of the circular muscles, being definitely grouped in six bands. These become larger and thicker as they approach the rectum. The spaces between the bands are evenly distributed and each contains a Malpighian tubule. Connective tissue closely holds the Malpighian tubules in place. (Fig. 12).

The circular muscles are well developed at the anterior end of the colon, but gradually disappear until only a few fibers are left near the posterior end.

As the course of the colon is observed towards the rectum, the epithelial cells become more and more flattened, and their boundaries become less distinct. Their protuberances into the lumen of the gut are irregular and give a distinctive wavy appearance to the intima.

THE RECTUM.

This region, similar to a cone in appearance, the narrow end terminating in the oval aperture, is characterized chiefly by its very abrupt union with the colon, (Fig. 13). A great enlargement of new circular muscle fibers make their appearance here and probably act as an intestinal valve. The sphinctor being thus formed, is much more developed than the one formed at the pyloric valve, hence this probably takes its place in function.

The circular muscles gradually decrease in number and thickness as the oval aperture is approached. The longitudinal muscles disappear entirely.

The intima at first is quite smooth but soon forms many folds which posteriorly become very pronounced, and somewhat tooth-like in appearance. Ordinarily these so-called "teeth" or rectal pads (Fig. 15) are six in number but in the case under discussion there is a marked irregularity. They probably vary in number from four to seven or eight, (Fig. 14).

At the anterior end of the rectum, the intima forms a bulge out into the body cavity. This evidently facilitates the attachment of the muscles of the colon and the origin of those in the rectum as well.

The epithelial cells are much smaller than those in the colon while the divisions between them are more pronounced. The nuclei are relatively large and contain large granular masses.

The chitinous spines as observed in the fore-gut are entirely lacking in the rectum as well as in the hind-gut in general.

THE MALPIGHIAN TUBULES.

These vessels are ectodermal in origin and therefore should be associated with the hind-gut. Their function is primarily urinary. Upon sectioning and staining the tubules, deposits of concretions are found scattered throughout the epithelium. These are probably depositions of such end products as uric acid, urates, etc.

In *Meracantha contracta*, the tubules are six in number and originate at the union of the mid-gut and hind-gut, being equally spaced about the gut. From this region of origin, they then course throughout the body cavity in general, winding about the viscera and finally becoming attached to the wall of the hind-gut at the point where the colon commences.

The method of attachment to the colon is very peculiar and worthy of especial notice. The six tubules come together and are much flattened and closely joined together by connective tissue, (Fig. 19) for a distance of about three millimeters before they branch out to course down the sides of the hind-gut. They do not coalesce into a common duct however, as each tubule can be separated out from the band. There is a sharp angulation in the direction the tubules take before they branch out from the band. The whole arrangement is certainly very specialized, and would appear to allow of the ready movements of the colon without bringing undue strain upon the tubules. There is a possibility that it is an adaptation to a special method of defecation. However this point needs further study.

From the points of attachment to the external wall of the colon, each tubule courses in a zig-zag manner down the wall between two bands of longitudinal muscles, (Fig. 20). They are in close contact with the wall of the intestine, being held fast by a thick sheath of connective tissue. As they continue down the colon, they become more compressed in nature and finally terminate blindly just before the beginning of the rectum. (Fig. 21).

The brownish color that is observed in various parts of the tubules is evidently due to the concretions previously mentioned. Near the point of origin they are nearly circular but become more and more flattened as they approach the point of attachment at the colon.

Histologically, it is observed, that they consist mainly of a thick epithelium, with an outer layer of connective tissue. The nuclei are very large, prominent, and filled with coarse granular chromatin. (Figs. 17-18).

Near their origin they contain a prominent lumen and the epithelial cells are densely packed with urinary concretions. Near their blind endings (Fig. 21) however, they become very bead-like in appearance, due to the large turgid epithelial cells, and greatly compressed, the lumen in many instances being barely discernible.

Conclusion.

In conclusion, it is to be noted that in this study of *Meracantha contracta*, there is much more to be accomplished before a complete understanding of the alimentary canal can be secured. More species of the Tenebrionidæ should be studied and comparisons drawn as to the adaptations in the canal, for the particular types of food eaten. There is no question that the type studied is very highly specialized. The degree of this specialization should be determined if possible. Also, the specimens studied show a high degree of parasitic infestation in the epithelial tissue of the mid-gut. This parasite is evidently intracellular in nature. In addition, there are present in the fecal material of the hind-gut, many single -celled organisms, obviously of a plant-like nature, possibly yeasts. These occur in great numbers, in strings and singly, in the posterior region of the gut, but are found only sparsely in the anterior region. These should be identified and their effect upon the alimentary canal investigated. In addition the relation of the nature of the bark eaten and the morphological adaptations should be compared. The physiology of the digestive system should be worked out with fresh material in order to understand the anatomical relationships.

In brief, it can readily be seen, therefore, that only a start has been made in this study, and that the pursuit of one problem has opened the need for investigation of many more.

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EXPLANATION OF PLATES.

Plate I.

Fig. 1. Dorsal view of the abdominal viscera and the portion of the alimentary canal visible.

Fig. 2. Ventral view of the abdominal viscera and the portion of the alimentary canal visible.

Fig. 3. Relative position of the alimentary canal including the Malpighian tubules, in the body of the insect. (Complete fore-gut not shown.)

Fig. 4. Longitudinal section through the head and fore-gut. The fore-gut is extremely short and the anterior end is marked by the powerful mandibles and molar crushing surfaces.

Fig. 5. Cross-section through a portion of the fore-gut. The thick layer of circular muscles is most evident in this section.

Fig. 6. Longitudinal section through the oesophageal valve. The spiny character of the fore-gut, the proventriculus, the flaps of the valve, the crossing of the longitudinal muscles from the fore-gut to the mid-gut and the circular muscle bands causing the ringed appearance of the mid-gut, are structures emphasized in this figure.

Fig. 7. Diagrammatic sketch showing the flaps or folds of the oesophageal valve.

Fig. 8. Diagrammatic sketch showing the relation of circular and longitudinal muscles at the anterior end of the mid-gut.

Plate II.

Fig. 9. Diagrammatic sketch showing ramifications of the tracheoles throughout the muscles in the walls of the mid-gut.

Fig. 10. Cross-section through a portion of the wall of the mid-gut. The nuclei fade out near the distal ends of the digestive cells, which are ruptured, allowing their secretions to be poured out into the lumen of the mid-gut. A heavy infestation of parasites occurs in the epithelium.

Fig. 11. Longitudinal-section through the pyloric valve, showing the nature of the valve and the abrupt transition from the mid-gut to the hind-gut. A Malpighian tubule is seen entering the lumen of the alimentary canal just anterior to the commencement of the chitinous intima of the hind-gut.

Fig. 12. Cross-section through the hind-gut in the region of the colon. The six strong bands of longitudinal muscles are illustrated, with the Malpighian tubules between them. The flattened character of the epithelium is noticeable.

Fig. 13. Longitudinal-section through the union of the hind-gut and the rectum. This sketch shows the thick layer of circular muscles in the anterior end of the rectum and the abrupt transition between the two regions.

Fig. 14. Cross-section through the rectum illustrating the rectal pads.

Fig. 15. Cross-section through a rectal pad. The surface of the pad is very convoluted and powerful circular muscles underly the epithelium.

Fig. 16. Longitudinal-section of a Malpighian tubule showing the large nucleus and concretions of waste products.

Fig. 17. Cross-section through a Malpighian tubule near its union with the alimentary canal at the pyloric valve.

Fig. 18. Cross-section through a Malpighian tubule near its attachment to the hind-gut.

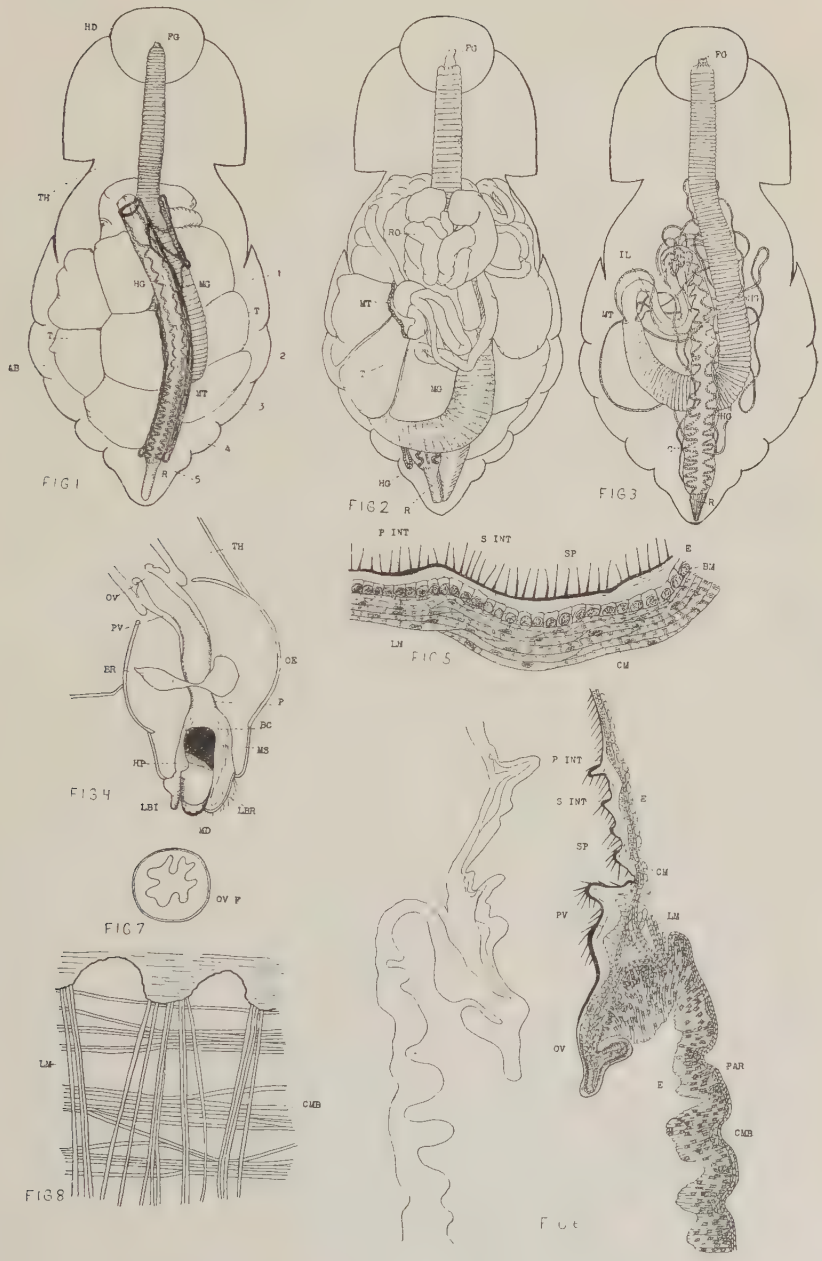
Fig. 19. A diagrammatic sketch of the peculiar band-like arrangement of the Malpighian tubules at the point of attachment to the walls of the hind-gut.

Fig. 20. Diagrammatic sketch illustrating the arrangement of the longitudinal muscle bands and the Malpighian tubules on the wall of the colon.

Fig. 21. Diagrammatic sketch showing the blind ending of a Malpighian tubule near the rectum.

ABBREVIATIONS USED IN THE FIGURES.

AB.....Abdomen.
BC.....Buccal cavity.
BM.....Basement membrane.
BR.....Brain.
C.....Colon.
CM.....Circular muscles.
CMB.....Circular muscle bundles.
CNS.....Concretions.
CT.....Connective tissue.
E.....Epithelium.
FG.....Fore-gut.
HD.....Head.
HG.....Hind-gut.
HP.....Hypopharynx.
IL.....Ileum.
INT.....Intima.
LBI.....Labium.
LBR.....Labrum.
LM.....Longitudinal muscles.
LN.....Lumen.
MD.....Mandible.
MG.....Mid-gut.
MS.....Molar surface.
MT.....Malpighian tubule.
N.....Nucleus.
NID.....Nidus.
OE.....Oesophagus.
OUF.....Oesophageal valve flaps.
OV.....Oesophageal valve.
P.....Pharynx.
PAR.....Parasite.
P INT....Primary intima.
PM.....Peritrophic membrane.
PV.....Proventriculus.
R.....Rectum.
RO.....Reproductive organs.
S INT.....Secondary intima.
SP.....Spines.
T.....Testes.
TH.....Thorax.
TR.....Tracheoles.
1, 2, 3, 4, 5..Abdominal segments.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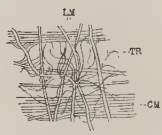

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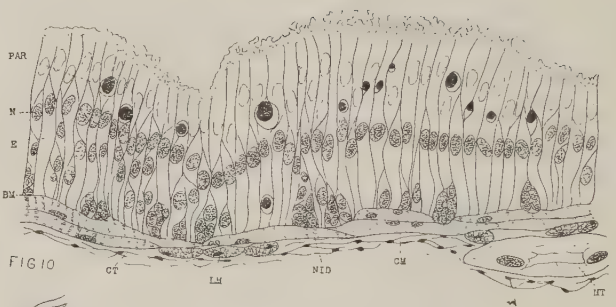

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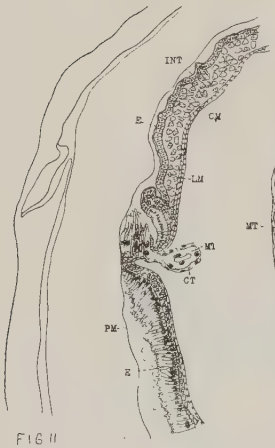

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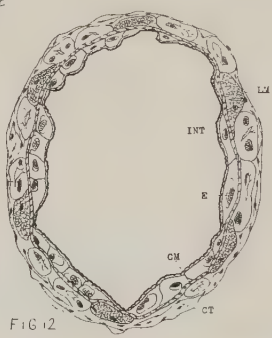

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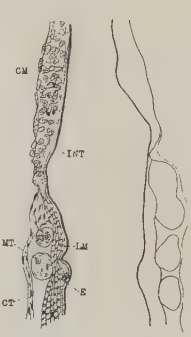

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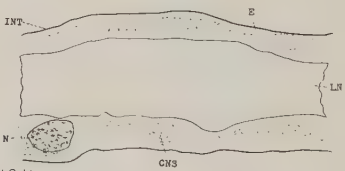

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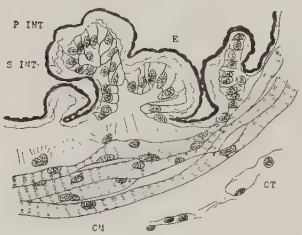

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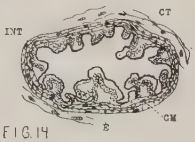

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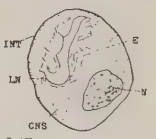

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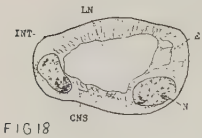

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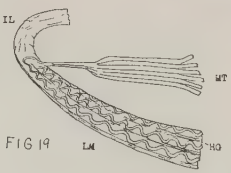

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FIG 20

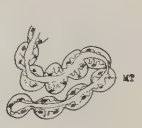

FIG 21

THE GRASS BALDS OF THE GREAT SMOKY MOUNTAINS OF TENNESSEE AND NORTH CAROLINA.*

W. H. CAMP.

Within the relatively small area comprising the Great Smoky Mountains of Tennessee and North Carolina may be found the richest flora, and surely, in its virgin condition, the most luxuriant deciduous forest on the whole North American continent. It is, with the rest of the great Unaka range, the natural dispersion center of the eastern deciduous forest, and contains such a relatively great number of endemic species that it stands unique as a vegetation center.

There are four major reasons for this unusual floristic development.

First.—The region is about four hundred miles north of the Gulf of Mexico and three hundred miles east of the Valley of the Mississippi, being thus assured of a fairly constant supply of moisture-laden winds.

Second.—The peaks are relatively high. There are seven in the eighteen miles between Clingmans Dome and Mt. Guyot that stand over 6,000 feet and in the whole Unaka range there are over forty of this type, with a considerable number of peaks having an altitude of more than 6,500 feet, many of them rising over a mile from their immediate bases. These altitudes are sufficient to keep the upper slopes almost constantly bathed in fog, a feature responsible for the name given these mountains. This type of relief has also given rise to deep, well protected valleys or "coves" with an abundant supply of moisture at the lower as well as the higher levels. The height to which the major peaks rise also brings about a constant floristic succession due to altitudinal effects.

Third.—The region was but little affected by the Pleistocene glaciation. The nearest continental ice was over two hundred miles away, with the Cumberland range a probable barrier to the incidental winds blowing from off the polar cap. In addition, the deep coves of the lower altitudes afforded ample protection during the occasional periods of lowered temperature.

Fourth.—The Appalachians, an almost unbroken chain, stretched for nearly a thousand miles in a north-easterly direction, tapping the reservoir of post-Cretaceous, circumpolar plant migrants.

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*Papers from the Department of Botany, the Ohio State University, No. 273.

THE BALDS.

There are two types of "balds" which occur in the Great Smoky Mountains, the "heath bald" and the "grassy bald." Both types are essentially treeless, the heath bald being dominated by woody ericaceous species, while the grassy balds appear to be consistently herbaceous.

Cain ('30), who made a statistical analysis of the heath balds of the Mt. LeConte area, concluded that they were post-climax, developing on the windward side of the upper slopes and peaks above 4,000 feet after the disturbance of the original forest. He recognized several types, depending upon the altitude at which they develop and the contiguous forest associations from which they were derived, being best developed as sub-alpine types above 5,000 feet in the spruce-fir zone.

The grassy balds, in the area under consideration, develop on the rounded tops and slopes mainly between 4,500 and 5,700 feet, and are surrounded by a deciduous forest. It is to be noted that the heath bald typically develops in the northeastern part of the area mainly within the limits of the spruce-fir zone, while the grassy bald is best developed in the southwestern part where the spruce and fir are absent.

THE GRASSY BALDS.

It has long been the belief of those who have speculated on the origin of the grassy balds, that the early settlers of nearly a hundred years ago cleared or burned off the tops of these ridges in order to produce a grazing place for their stock. It is not the purpose of the present writer to cast any aspersions on the actions or purposes of the pioneers who settled in the broad fertile valleys such as Cade Cove, but it does not seem reasonable that those sturdy peoples, frugal as they were, would have taken the trouble to make such an extended system of pastures as has existed for at least a century.

The pastures would have been over 3,500 feet above their home sites and five or ten, or more, miles distant, necessitating either the removal of responsible members of the family from the fields below, or the hiring of special herders for the stock, the general plan at the present time. Roads had to be built*

*Making a new road to the "top" was a community event and was a matter of deep concern. Early in the last century a road was to be built from Cade Cove to the top in the general direction of Thunder Head. The argument waxed hot

and the water supply, at best not overly abundant on the balds, had to be watched. It seems to the writer, rather, that if these early settlers went to the trouble to burn and clear these distant mountain tops, they did it merely to *enlarge grassland areas already present* and not to create new ones.

It is true that grazing and fire have been the important factors in the changing physiognomy of the balds, but with this in mind, an examination of the region over a period of three years and at various seasons from the Little Tennessee River (1,500 ft.) to Parson Bald (4,700 ft.), and from Cade Cove (1,800 ft.) to Gregory Bald (4,957 ft.), and along the state line ridge to Little Bald (4,700 ft.), gave no hint that these factors have been the ones which gave rise to the typical grassy bald.†

FACTORS IN THE DEVELOPMENT OF THE GRASSY BALD.

In the northeastern portion of the Great Smoky Mountains abundant stands of spruce and fir occur at the higher altitudes. In ascending a typical mountain in this portion of the area, such as LeConte (6,593 ft.), one may observe that the rich lowland mixed forest (1,500 ft.) soon gives way to a dryer forest containing a greater percentage of oak and chestnut and finally pine. Within a few hundred feet the situation is reversed; the pines give way to the oak-chestnut type. At still higher elevations the maple, and beech moves out of the coves and onto the slopes. Above 4,500 feet the beech appears on the ridges where it mingles with the birch and finally above 5,000 feet with the spruce and fir, often occurring in pure stands, but dwarfed by the moist cool climate of the higher altitude. The spruce and fir occur on the higher slopes and peaks, in the region of almost perpetual fog.

There is no doubt about the constant water supply of the spruce-fir forest, for when the writer visited the area in September following the most unusually dry summer of 1930 there seemed to be no great dearth of soil moisture at the higher elevations in spite of almost complete lack of rain since June.

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as to which of two ascending spurs should be chosen. A vote was then taken and it was a tie. One of the settlers who had not yet voted, a native of northern Europe, said: "I bote vor dis vun." In the "Cove" they still speak of "Bote Ridge" and "Defeat Ridge."

†The writer has not made a study of the most easterly balds, as Silers Bald; consequently any statements do not include that area.

During the summer season there is an almost continual patter on the forest floor made by condensed moisture dripping from the trees. In addition to the "drip rain" of the spruce-fir forest, these mountain tops usually have an annual precipitation perhaps in excess of 60 and sometimes estimated at over 80 inches.*

It is thus evident that there is a reversal in the forest types as one ascends in the northeastern part of the area, the lowland

FIGURE 1. GREGORY BALD.
The general aspect of the eastern margin of the bald. The grass in the foreground is mainly *Danthonia compressa*.

forests being mainly moist and warm, the middle forests dry and the upper again moist but cool.

The ascent of a mountain in the southwestern portion of the area typically gives the following gross succession. This particular one is taken on the main northeast facing ridge rising from Cade Cove to Gregory Bald.

The valley of Forge Creek (2,000 ft.) contains the usual rich, mixed deciduous forest with hemlock, white pine and rhododendron. Above this, the exposed slopes (somewhat modified by excessive cutting and fire) soon change to an oak-

*No data is available for the peaks of the Great Smoky Mountains, but comparable altitudes in the Blue Ridge have an annual precipitation of nearly 100 inches.

pine complex. At 3,000 feet the pines are very abundant, giving way to the chestnut-chestnut oak type at 3,500 feet. Above 3,500 feet the chestnut oak is slowly replaced by red oak.

Above 4,000 feet an occasional beech is seen, the dominant forest being red oak-chestnut-red maple-chestnut oak with an occasional magnolia (*M. fraseri*). At 4,500 feet the red oak-chestnut-red maple type is still dominant, but in the sag (about

FIGURE 2. GREGORY BALD.
Detail of the southern margin of the bald. The trees (red oak and chestnut) are 6–10 feet tall. The browsed shrubs are mainly Vaccinium and Salix. Figures 1 and 2 were taken in a driving fog.

4,750 ft.) just below the bald, beech is much more common, with a scattering of birch and buckeye. Within the next 50 feet the mesophytic species disappear leaving a practically pure stand of chestnut-red oak. As one ascends, this chestnut-red oak forest becomes more and more stunted until it is less than twenty feet high, suddenly giving way to a low, dome-shaped treeless area—Gregory Bald—at an elevation of 4,957 feet. (Fig. 1).

At first glance the bald seems to be an open grassland completely devoid of woody species, the low meadow vegetation stopping abruptly at the edge of the dwarf forest. A closer

examination reveals that in a few places shrubs six to eight feet high occur between the open grassy area and the forest. A still closer examination shows that the meadow is by no means a pure herbaceous association, but has a zone around the edge sometimes over fifty yards wide, which contains a high percentage of woody species so closely browsed that whole areas may stand less than six inches high. (Fig. 2.) These areas of browsed shrubs are by no means confined to the margin of the bald, but occur in scattered patches over the lower slopes, thinning out toward the top.

The determination of the species making up the woody flora of the bald has been exceedingly difficult owing to the closely browsed condition of the plants. Consequently the writer does not feel justified in presenting a floral list and in those plants noted freely admits the possibility of error.

In September, 1930, the larger shrubs of the bald were Crataegus (*C. macrosperma* and possibly *C. roanensis*) and Azalea (*A. lutea*). The smaller shrubs were represented by Vaccinium spp., (one type somewhat resembling *V. corymbosum*), Salix spp., (*S. tristis* often formed dense mats, while another form with sprouts about one foot high greatly resembled *S. discolor*. *S. humilis* may also have been present) and in addition, numerous clumps and individuals of *Xolisma ligustrina*. *Epigaea repens* also was fairly common.

The more open grassy areas contained an abundance of *Danthonia compressa* and *Juncus tenuis* with additional grasses, sedges, etc., and other herbaceous types, such as the pin-weed, *Lechea* (*L. racemulosa* or *L. leggettii*) and *Viola pedata*, including a goodly number of obviously adventive "weeds" of the lower pastures.

Because of the scantness of remains of the original covering and the evident disturbance of occasional fires and decided over-grazing, it is very difficult to reconstruct the original vegetation type of Gregory Bald as it was before the advent of the white man. In his general statement concerning the grassy balds, Cain ('31) concluded that they are natural phenomena for the "soil profiles show from a few inches to a foot or more of homogenous black soil of grassland type, which is too deep and mature to have developed since the advent of the white man, with the possibility of his having cleared off the trees."

While in general this statement is correct, the writer encountered a certain unevenness or "spotty" nature in the distribution of the black soil. In certain restricted areas this could be traced to excessive erosion initiated by the pawing of animals, particularly sheep. However, taken as a whole, this is not true for the bald and it is the opinion of the writer that the area was not originally a pure grassy meadow, but one with numerous "shrub islands" of various types. This view was substantiated by Mrs. John Oliver, long a resident of Cade Cove, who said that she "had it from the older folks long dead" that Gregory Bald was "originally a blueberry meadow" and had "always been a bald."

The present high percentage of willow in the shrub population is no doubt due to the ease with which willow regenerates in heavily grazed areas by vegetative means. It is also true that grazing, particularly by sheep, is decidedly injurious to certain Ericaceous species. With this in mind, it seems probable that Gregory Bald was once dominantly a heath bald, containing open spaces with a heavy covering of grasses, sedges and other herbaceous species. This type of bald is distinctly a dry one, having little in common with the heath bald developed at the higher altitudes in the moist spruce-fir zone, and is easily the dryest bald type of the whole Great Smoky Mountain range.

In considering the factors underlying the production of the "grassy bald," the writer has already mentioned the fact that in the area where the grass balds develop there is a sudden appearance of a scrub forest near the top of the ridge, the last forest sometimes being a stunted chestnut-red oak type. The altitude and steepness of slope are not the determining factors, for comparable altitudes and steeper slopes some miles to the northeast support a thick stand of beech, birch, spruce and fir. The writer can give no plausable causative factor other than the following. These balds occur in the southwestern portion of the range and are more exposed to the dry and sometimes hot southwesterly winds that occasionally sweep in across the valley of the Little Tennessee River in mid-summer. The effect of these desiccating winds is easily noted by climbing from the river to Parson Bald or Gregory Bald, for as one ascends, the forest becomes more open and park-like with numerous small grassy areas often containing a considerable dry heath population. It is not meant to convey the impression that all the

southwesterly winds are dry and hot, for the grassy balds are often bathed in fog, but in mid-summer there are occasional periods of excessive drought, and it is this extreme that limits the character of the bald rather than the general climatic mean.

SUMMARY.

There are two major types of treeless areas or "balds" which occur in the Great Smoky Mountains of Tennessee and North Carolina, the "heath bald" and the "grassy bald."

The heath bald typically develops on the upper slopes and peaks, being best developed above 5,000 feet in the northeastern part of the range mainly within the area of the spruce-fir forest.

The grassy bald develops on the rounded tops and slopes between 4,500 and 5,700 feet in the southwestern part of the range and is surrounded by a deciduous forest.

A study of the area surrounding Gregory Bald led to the following conclusions:

1. The grassy balds were originally meadows containing numerous clumps of low shrubs, dominantly Ericaceous, with higher shrubs at the margin.
2. The balds were already present at the advent of the white man.
3. Any clearing that the early settlers did was not to produce grassland areas, but merely to enlarge those already present.
4. The grassy balds of the *southwestern portion* of this range are a natural phenomenon probably produced by occasional desiccating southwesterly winds, their grassland character being intensified during the last century by fires and decided over-grazing.

The writer wishes to acknowledge the assistance of Prof. J. H. Schaffner, of the Ohio State University, in the identification of certain plants, and the suggestions given by E. F. McCarthy, Director of the Central States Forest Experiment Station, who spent a number of years in this general region.

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A PRELIMINARY POLLEN ANALYSIS OF THE EAST McCULLOCH PEAT BED.*

GEORGE H. LANE.

This paper reports the results of a preliminary study of a column of peat taken from the East McCulloch peat bed in northern Iowa. The object of the completed study will be to reconstruct the course of post-glacial climate in that region. The present report must of course be regarded as subject to future modification and correlation.

The percentages of pollen found preserved at successive depths of the peat bed have been taken to indicate the composition of the vegetation about the bog when successive strata of peat were formed. Changing percentages of pollen are construed as suggesting a changing vegetation and a corresponding change in climate.

THE PEAT BED.

The East McCulloch peat bed lies in Section 32, Twin Lake Twp. (Twp. 94 N, R 24 W) Hancock county, in north central Iowa. It covers an area of perhaps eighty acres. The bog was drained in 1920.

Hancock county lies near the eastern edge of the area once covered by the Wisconsin glacier. The soil survey of Wright county (1) (just south of Hancock county) describes the topography of that county as follows: "The country has two general types of topography, a relatively smooth till plain and a morainic hilly region. A line drawn from the center of the northern boundary of the county to a point on the southern boundary about five miles west of the southeast corner will roughly divide the till plain on the west from the morainic hills on the east." The soil survey of Hancock county is not yet available but the range of morainic hills mentioned extends on northward into this county. The East McCulloch peat bed lies about a mile within these hills.

Presumably, these hills mark a period of slow recession with numerous readvances of the glacial ice while the comparative

*Contribution from the Botanical Laboratory of the University of Oklahoma, N. S. No. 10.

smoothness of the till plain would suggest rapid melting. Since the East McCulloch peat bed lies just within these morainic hills, its pollen record may be expected to include most of the period following the beginning of the rapid retreat of the ice.

MATERIALS AND METHODS.

Samples were taken during the summer of 1929 with a Davis peat sampler at six inch intervals through the depth of the peat bed. These were temporarily wrapped in newspaper

TABLE I.

Fossil Pollen by Percents for Each Foot of Depth in McCulloch Bog.

	Top	1′	2′	3′	4′	5′	6′	7′	8′	9′	10′	11′	12′	13′	14′	15′
Abies	1	....	....	3	2	1	....	....	....	1	5	16	....	**24**	....	11
Acer	....	....	....	....	1	....	....	....	....	....	1	....	....	....	....	....
Amaranthaceæ and Chenopodiaceæ	6	....	3	**32**	**32**	**37**	5	11	**21**	**17**	6	....	....	....	....	....
Betulaceæ	....	....	1	1	....	....	....	....	1	1	11	**28**	....	**16**	....	1
Carya	....	....	....	1	3	....	4	2	5	5	5	....	....	1	....	....
Compositæ	1	4	7	1	3	....	3	1	4	7	3	1	....	3	....	2
Cyperaceæ	21	4	....	7	14	7	7	10	8	7	6	3	....	1	....	....
Fagus	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	....
Gramineæ	**39**	**74**	**70**	**33**	**24**	**35**	**69**	**60**	**23**	**17**	13	14	....	5	....	3
Juglans	....	....	....	....	....	....	....	....	....	....	1	....	....	1	....	....
Picea	1	....	2	1	1	....	....	1	1	1	1	8	....	**20**	....	**69**
Pinus	1	4	1	1	2	3	1	1	4	5	4	1	....	6	....	11
Potamogeton	1	....	....	1	1	1	....	....	....	....	1	....	....	....	....	....
Quercus	3	5	4	2	6	4	3	4	**20**	**27**	**28**	14	....	11	....	3
Salix	1	....	3	1	2	....	....	2	2	1	....	....	....	7	....	..
Sparganium	5	1	....	1	1	10	....	1	2	....	3	4	....	....	....	....
Tilia	....	....	....	....	1	....	....	....	1	....	1	....	....	....	....	....
Typha	....	....	1	....	1	1	....	....	....	1	1	....	....	1	....	....
Ulmus	....	....	....	....	....	....	....	....	....	....	1	1	....	1	....	....
Unknown	20	8	9	16	7	2	8	8	9	11	9	9	....	4	....	1

and later transferred to one half pint tin paint cans and treated in a pressure cooker to prevent bacterial action. When opened in the laboratory the samples were in perfect condition.

Separation of the pollen from the peat was accomplished in the usual way (3). All reagents used were filtered.

The determinations of the pollen were made with the aid of the key and drawings of Sears (2). Dr. Sears' personal collection of fresh pollen slides was also very helpful in many cases. In a great many instances the oil immersion lens was resorted to for identification of the pollen. For such forms as

Quercus, *Salix*, *Acer*, and in many cases the Gramineæ, the oil offered means of certain identification when the 4 mm. lens left some doubt.

RESULTS AND DISCUSSION.

Table I is a complete list of all pollen counted from the peat core. Each six-inch level was studied separately and the resulting numbers were totaled for each foot of depth. At least one hundred pollen grains were counted from each six-inch level. The presence of spores of Fungi, Bryophytes, and Pteridophytes was noted but they were not included in the total on which the percentages were based.

The groups which appear in greatest numbers at each level are indicated by bold faced type in each depth column.

Figure 1 is a diagram showing relative abundance of pollen of different taxonomic groups at each depth.

At fifteen feet spruce pollen is most abundant with other conifers making up most of the rest of the pollen found. Spruce diminshes greatly at thirteen feet but maintains parity there with fir and birch which have increased greatly. Birch forges to the front in quantity of pollen at eleven feet while fir is disappearing and oak and grasses appear in moderate quantities. At the ten and nine foot levels birch, spruce, and fir are markedly on the wane while oak appears in increasing quantities. In the nine foot level amaranthaceous pollen makes its first considerable appearance. Amaranth reaches major proportions in the eight foot level while oak is diminishing and grass remains practically constant. At the seven and six foot levels grass pollen becomes the major constituent and amaranth pollen is considerably less abundant. All tree pollen is comparatively rare in the seven foot and succeeding levels. At five, four, and three feet amaranth pollen again becomes a major part of the pollen found but it again disappears in the three upper levels as grass pollen again increases.

Assuming these pollen percentages to represent the composition of the vegetation the changes shown in this peat bed are—(1) spruce forest, (2) mixed fir, birch, and spruce, (3) birch with fir and oak, (4) oak with birch and grasses, and (5) grassland vegetation from here up with a strong semi-arid element at the nine to eight foot levels and again at the five to three foot levels.

Again assuming that these vegetation units have been dependent in the past on the same climates that control them

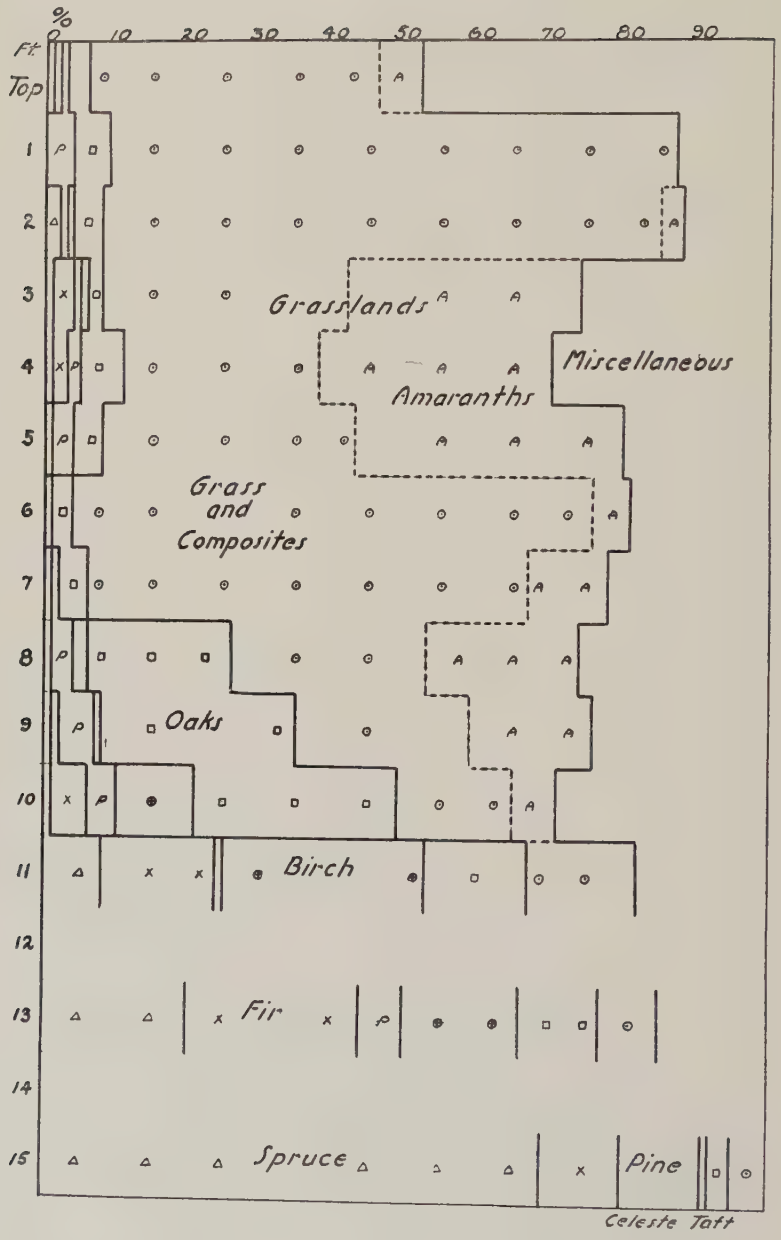

FIGURE 1.
Porportions of different fossil pollen at successive depths.

today we may draw three climatic inferences from this succession of vegetation, (1) warming influences which accompanied the change from coniferous to deciduous forms through the lower quarter of the peat bed; (2) gradual dessication of the climate through the lower half of the peat bed culminating at eight feet; and (3) continuous grassland climate from this point onward with a second period of dessication which reaches a maximum about the four foot level.

In figure 2 the pollen of each genus or family is graphed in columns representing their probable climatic preference.

The following table presents this grouping:

TABLE II.

Assumed Climatic Significance of Fossil Pollen.

Unknown	Lake Margin Plants	Coniferous Forest Climate			Deciduous Forest Climate			Grasslands Climate	
		Moist	?	Dry	Moist	?	Dry	?	Dry
	Cyperaceæ Potamogeton Salix Sparganium Typha	Abies	Picea	Pinus	Acer Fagus Juglans Tilia Ulmus	*Betulaceæ Quercus	Carya	Gramineæ Compositæ	Amaranthaceæ

The climatic shift suggested above is borne out in the chart, Fig. 2. Coniferous pollen is of little importance above eleven feet. Herbaceous pollen is most abundant above nine feet. Deciduous tree forms are important only in the eleven to nine foot levels. Correlated with sharp increases in the "Grassland-Dry" column are sharp increases in the column "Lake Margin Plants." It would be expected that climatic dessication would result in lowering lake levels and an increase in these plants. Increase in the latter in the "Top" level where there is no corresponding increase in the "Grassland-Dry" column is largely Cyperaceæ pollen and is probably a result of draining the bog.

That the phenomena indicated above the thirteen foot level are to be correlated with the two dry post glacial periods postulated by Auer (5) and Sears (4) appears likely from the fact that this column runs well back into the post glacial coniferous forest period.

*The Betulaceae may with some reason be regarded as indicators of a cool dry phase of the deciduous forest climate. This is consistent with their position in the accompanying charts and agrees with results obtained in Indiana, shortly to be published.—P. B. S.

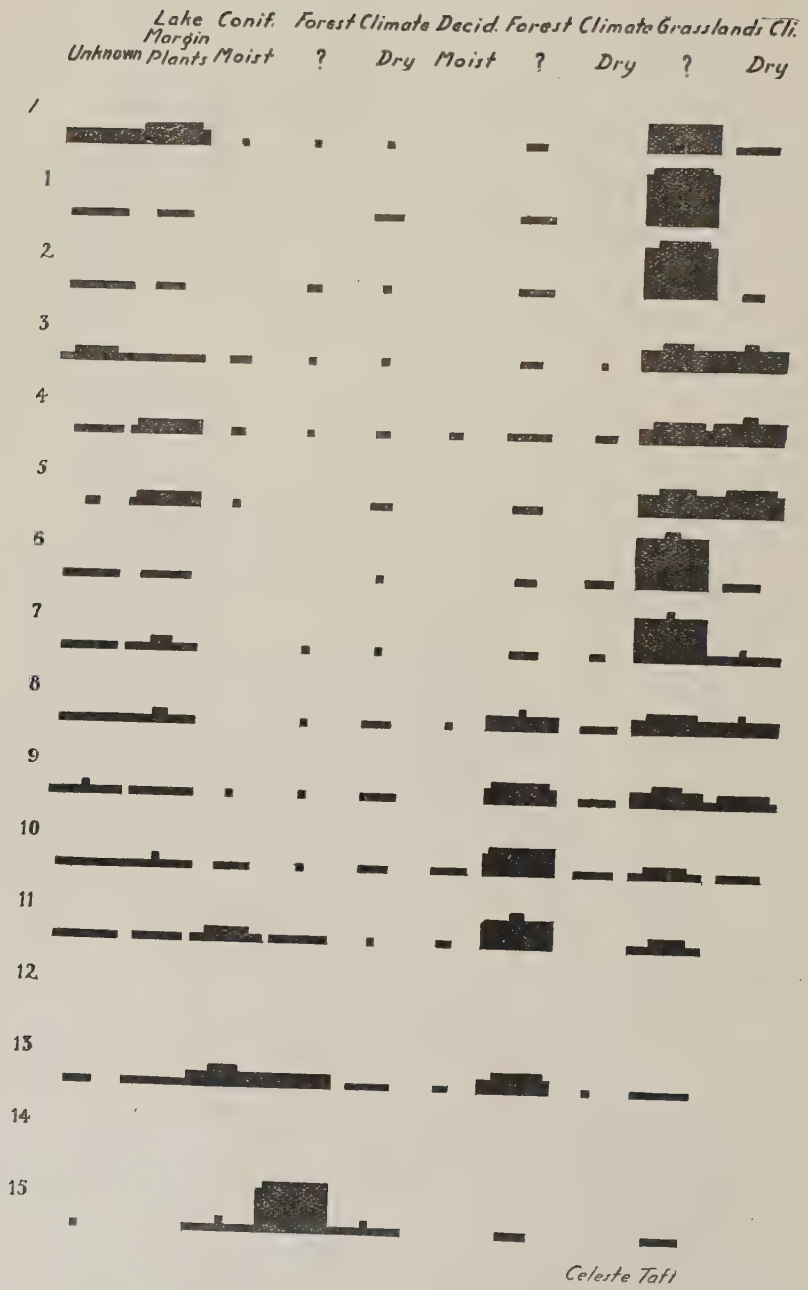

Fig. 2. Proportions of different fossil pollen at successive depths, grouped by probable climate significance.

Above eight feet but little tree pollen is to be found though there is some in each level. Each genus varies from level to level but these variations are of too low an order to be regarded as significant. There is no indication from this study that the forest is replacing grassland in Iowa. It would seem, on the other hand, that the status of the Iowa Prairie as a climax formation would be strengthened since it appears to have developed in the place of a former forest as a response to present climatic conditions.

SUMMARY.

1. Pollen analysis has been applied to the study of peat from the East McCulloch peat bed in south central Hancock county, northern Iowa.

2. Fossil pollen found suggests the following succession of vegetation: (a) Spruce at 15 ft., (b) fir with spruce and birch at 13 ft., (c) birch with fir and oak at 11 ft., (d) oak at 10 and 9 ft. with entrance of herbaceous forms at 9 ft., (e) grasslands from 8 ft. upward with considerable amaranthaceous flora at the 8 ft. and at the 5, 4, and 3 ft. levels.

3. Climatic changes inferred from changes in the vegetation are, (a) warming from 15 ft. to 10 ft., (b) gradual drying from 15 ft. to 8 ft., and (c) grassland climate above 8 ft.—of distinctly arid type at the 8 ft. and at the 5, 4, and 3 ft. levels.

4. No indication was found of recent increase of forest although recent conditions appear to be more humid than those of the 3 ft. level.

The author desires to acknowledge his indebtedness to Mr. W. H. McCulloch for the freedom of his farm and for assistance in collecting samples and particularly to Doctor Paul B. Sears, who suggested the problem, for his help and encouragement throughout the course of the investigation.

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"BIRD SANCTUARY" SUGGESTIONS.[1]

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"Bird Sanctuary," as intended in the management of Parks, Estates, Cemeteries, or Golf Grounds, really means the conservation of wild life of all kinds, birds, mammals, wild flowers, and all the other interesting things in nature.

This needs to be carefully distinguished from the "shooting grounds," or "pheasant raising" idea of sportsmen whose chief aim is to kill. We believe, then, in the least possible destruction of wild life in a Bird Sanctuary, and that means that coons, possums, and skunks may live there safely and undisturbed. These animals, and especially the skunks, are of great value, where there are lawns, because of their destruction of insects injurious to lawns.

Hawks are mostly useful and valuable, except one or two species, as they are great destroyers of insects and rats and mice. All the wild creatures live and survive and find their place in nature, except as man upsets the balance.

Sanctuary then, to all wild life in order that we may enjoy seeing and knowing them.

Kill? Kill all cats as the worst enemies of all forms of wild life; we must appreciate that, under the protection of civilized life, cats prosper beyond control and become wild and enormously destructive. Do not shoot a cat! It disturbs the neighbors. But cats may be easily trapped. Use traps that do not kill when sprung; this because the traps may catch other forms of life which should be released unharmed.

English Sparrows may be very abundant and consume the grain intended for more desirable native birds. Do not allow English Sparrows to be trapped unless by a person who knows our native sparrows very thoroughly. Our native sparrows closely resemble the English Sparrow, in appearance, but are, in fact, most desirable and attractive birds to cultivate. Consult an expert if you need trap English Sparrows. Red Squirrels

[1]Contribution No. 20 of the Baldwin Bird Research Laboratory.

do seem destructive to birds and should be trapped and destroyed if they become abundant.

Do not destroy any other wild life unless, in special cases, where some serious damage is done.

"Bird Sanctuary"—a popular idea of it is that a limited area be set aside, only a few acres sometimes, and that this be left to the birds, and without habitation of man.

This idea of a bird sanctuary is based upon two mistaken notions:

(1) That the birds will concentrate in such an area for their nesting; this completely ignores the fact that, with the exception of a few colony nesting birds like the martins, or certain sea birds, most of our common birds have a strong claim to territory. A book written about "Territory in Bird Life," by Howard, an Englishman, has made us all realize that each pair takes possession of and holds, during nesting, a feeding territory, and the birds will not concentrate or crowd into a limited area. It is nature's provision to keep them spread out over wide areas for feeding.

(2) That birds thrive better away from human habitation and activities, the fact being that few birds mind in the least the usual activities of human life, about them, and indeed, except for cats, the proximity of human life is a protection to them.

Coming now to more definite suggestions:

(a) A program for a Bird Sanctuary should cost very little in time, labor or money.

(b) The area may be large, full size of park, cemetery, estate, or, indeed, an entire community or village or suburb.

(c) One prime need is some person in charge who is interested and loves the wild life, who can give for an estate or cemetery, two or three half days per week in winter. In selecting the person, find one who will not be tempted to take advantage of the position to trap for pelts.

(d) All year, but especially in spring, operate a few cat traps now and then. *Get rid of cats;* when in trap they may be treated with a spoonful of chloroform, or of carbon disulphide poured in the trap, but be sure the cat is dead, not just asleep before burying, and *Caution*, the gases are poisonous to breathe and very inflammable. Cats may come from a mile or more about, and usually at night, so do not think the wild life is safe just because you do not see cats about in daytime.

(e) During the spring and summer no feeding need be done, but it is very desirable that some nest places be provided; also good cover of living shrubs, and brush and evergreens.

(f) Nest Places: Where there are trees in the natural state of some being rotten or broken, and bored by woodpeckers, it is usually not necessary to provide artificial nest boxes. But

the modern tree surgery, where thoroughly done, results in closing up or cutting out every possible nest site for the birds nesting in holes or boxes. Nest boxes may then be provided in any of the simple forms, not too many, not more than four to the acre; and all boxes must be so made that the top or side may be opened for cleaning out.

(g) Winter Feed Shelters: Suitable to attract and protect quail and all the other birds.

FIG. I. An Effective Form of Food Shelter.

Square simple wood frames, four corner posts, and waterproof roof; rough sides, especially on north and west, one side on the east or south entirely open, but, on at least two sides, boards must be off at the base so birds may escape if an enemy suddenly appears at the open side. Feed may be thrown on the ground under the shelter; and a second feeding place provided by constructing a floor, or platform, two feet above the ground.

The best protection requires that coarse brush be piled about and in the shelter to prevent the possible sudden rush or attack by enemies, and give the birds a chance to escape, in case of such attack.

Supply here constantly, fine gravel, sunflower, buckwheat, cracked grain, or poultry scratch feed, and some minor portion of finest baby chick food for the smallest birds, suet, fruits, apples, or dried fruits, water if it is very far to water. Not too much grain at a time or it will sour.

(h) Planting to provide shelter and feed: Cover is most important, thickets, shrubs, and wherever possible let the thickets become dense and tangled, and where possible let the weeds grow in wild abandon; the thickets provide shelter from enemies, shelter from sun, and shelter for nests; the weeds provide winter feed that will stand above the snow, however deep. Ravine banks planted to evergreens provide warm shelter for winter.

(i) Water is most important. Sometimes, along a brook, walls are built with much care and expense; these walls may completely prevent not only small mammals but even birds from access to water. Allow gaps or breaks every hundred feet to allow access.

Planting for Food Supply:

For summer:

Mulberry	Thorn
Bird Cherry (Prunus)	Bush Honeysuckle
Elder	Shad Bush

For autumn and winter:

Thorn	Alder
Mountain Ash	Viburnums
Crab Apples	Wild Grapes
Barberry	

Books Devoted Especially to this Subject:

"Bird Friends," by Gilbert H. Trafton, Houghton Mifflin Co., 1916. A very complete handbook on attracting and protecting birds.

"Wild Bird Guests," by Ernest Harold Baynes; E. P. Dutton & Co. Now out of print, but may be picked up from dealers in second-hand books. Several other interesting little books by Baynes. Apply to Audubon Birdhouse Co., Meriden, N. H.

The "Book of Bird Life," by Dr. A. A. Allen, of Cornell; D. Van Nostrand Co., N. Y., 1930.

"Golf Clubs as Bird Sanctuaries," by A. A. Allen. Apply to National Association of Audubon Societies, 1974 Broadway, New York City.

"How to Make a Cat Trap," Leaflet No. 50. For sale by Superintendent of Public Documents, Washington, D. C.; 5 cents.

For traps, write to: A. W. Higgins, Rock, Mass., or Russell S. Davis, Clayton, Ill. (Both will supply bird and cat traps.)

For bird homes, write to: Audubon Birdhouse Company, Meriden, N. H.

For books to identify birds:

Birds of New York, 106 plates, $1.00 and postage. New York State Museum, Albany, N. Y.

Birds of New York, two large volumes, same plates, $10.00. New York State Museum, Albany, N. Y.

Birds of Massachusetts, by Forbush; three volumes finely illustrated; $15.00. Apply to State Ornithologist, State House, Boston, Mass.

Birds of Pennsylvania, by Sutton; small hand book, $1.25. J. Horace McFarland Co., Harrisburg, Pa.

Hand Book of Birds of Eastern North America, by Frank H. Chapman. D. Appleton & Co. The standard hand book.

BOOK REVIEW.

HISTORY OF APPLIED ENTOMOLOGY. L. O. Howard. Smithsonian Institution, Washington, D. C., 1930.

Entomologists who have been waiting expectantly for Doctor Howard's "History" will be delighted with the appearance of this fine volume filled with anecdotes and reminiscences of the author's fifty years participation in the growth of entomology. The sub-title, "somewhat anectodal," indicates well the nature of the contents, as the work consists very largely of accounts of Doctor Howard's personal associations with entomologists during the past fifty years. For many of the incidents related one would look in vain in any official report or publication. Quite naturally the space devoted to early American entomology deals very largely with the growth of the Federal entomological service, in which Doctor Howard had so prominent a part. His treatment of the growth of entomology in the several states and especially in the Experiment Stations is relatively brief and, as he states, no attempt is made at completeness. A particularly fine feature of the work is the inclusion of some 250 portraits of American and foreign entomologists. The omission of some well known American workers is explained by the statement that portraits were not included for men under fifty-five years of age. H. O.

MODERN BUILDINGS AND THE TERMITE PROBLEM.

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A recent paper on the subject "Termites Modify Building Codes"* by Dr. T. E. Snyder, has called to our attention the modifications in building codes which have been brought about by the continued and enormous damage of termits in all sections of the United States, but especially the south and southwest. He has stressed three principal points—the insulation of untreated woodwork from the ground by means of proper foundations and proper mortar, metal termite shields to shut off the shelter tubes or tunnels composed of earth, and treatment of interior woodwork and furniture with preservatives. This new building program will undoubtedly bring about decided changes in both the type and permanence of buildings in many parts of the country due to new methods, materials, and new treatments of wood which is used in construction. Such a modification should reduce greatly the more important infestations and losses.

If we confine our attention entirely to the modern building where for the most part the normal precautions for termites have been observed we still find a high percentage of infestation. It is the general opinion even of the average entomologist that the termite should be a factor of minor importance in buildings with modern construction especially in the north, but it is surprising how many buildings are infested and how severe these infestations frequently become. In view of the fact that so many of these have come to the writer's attention during the past few years and many attempts have been made to control them, it might be well to state briefly certain conditions found and problems encountered, all of which are in keeping with the conditions mentioned by Dr. Snyder except that the infestations that are cited here are found in the modern homes in some of the newest and most exclusive subdivisions of Columbus. The building cost of these structures will range from $20,000 to $60,000 at least, and the most modern methods of construction and best materials have apparently been used as

*Jour. Econ. Ent., Vol. 20, p. 316. April, 1927.

far as possible. The proportionate losses are naturally not so great but the termite remains a problem even here and continued losses are suffered.

The subterranean termites have been found to be the type concerned in all infestations observed. These are able to attack wood only by maintaining contact with the earth in order to obtain moisture which is necessary for their survival. If they cross brick or concrete foundations in order to reach wood sills or other timber they construct earthen shelter tubes.

Observations have shown that houses constructed chiefly of brick, stone or concrete, are frequently infested and it is just as easy to find such a modern structure infested as it is to find a modern frame house, with a good brick or concrete foundation, which is infested.

The usual locations of termite infestation, as observations would indicate, in a house constructed chiefly of brick or similar materials, is the hardwood floors. A large number of such infestations have been seen in Columbus where the floor was damaged to the extent that only a very thin shell of wood remained above and eventually some one would walk upon this and it would easily break through. This condition is found especially in corners or other parts of the room where furniture is placed over certain portions of the floor and remains there for some time so that no one walks upon these places for a considerable length of time. It is therefore necessary to replace whole sections of hardwood floors or in many cases boards here and there throughout the room. In either case refinishing of the entire floor is usually necessary. The sub-floor and joist are sources of infestations in many cases. Frequently the whole floor becomes perforated with emergence holes. Other common places of infestation in the modern house are the door sills and door and window frames and casings, large wooden supporting beams, studding and similar structures.

In attempting to trace the source of these infestations it was found that in some cases termites were entering through crevices where the mortar had cracked or crumbled away, or had been removed apparently by these insects forming small passageways between the bricks of the foundation so they could enter here. The termites after entering were working up the brick or concrete wall inside then following a large beam or some wooden structure to the center of the building and working up into the floor and other portions of the building

from this point. Attention should probably be called to the conditions which usually favor such a source of infestation. As a rule after excavating for a building and constructing the foundation, a sort of trench remains for some time outside the foundation while the super structure is being constructed. Wooden refuse of all kinds, but composed chiefly of small pieces which have been sawed off and dropped, fall into this trench and are later covered with dirt when the surroundings are graded and landscaped. This forms an ideal condition for termites and is a common source of infestation for the home, as excavations have demonstrated, for they come through the walls frequently below the outside surface or ground line. Antique and other furniture frequently contain termites which destroy the wood and consequently the value of these articles within a short time. In addition, evidence would indicate that this is probably the source of infestation for woodwork and other portions of the household in a few cases where such articles of furniture have been brought into the home.

Probably the most extreme and striking examples of termite infestations are in modern fire-proof buildings. A few such structures are known to be infested in Columbus, although the source of infestation, in many cases, is rather difficult to ascertain. These infestations are found in buildings of brick or concrete construction, finished with metal lath, composition floors and baseboards, metal and glass doors throughout, the only wooden portions being the door casings which are infested and the interior window frames. The losses here of course are comparatively slight as a rule but these are good examples of the extreme conditions under which termites occur in modern buildings.

As a specific example of an infestation of this type and one showing a loss of several thousands of dollars I might cite the recent discovery of termites in large numbers in the basement of the Ohio State University Library. This building was erected in 1913 at a cost of approximately $250,000 (it would cost $400,000 to duplicate it now) and constructed entirely of reinforced concrete, stone and similar materials. No wooden structures of any kind are found in the basement except some tables, chairs and temporary shelves for sets of old periodicals. Upon investigation it was found that when the concrete was poured for the floor of the basement, very minute pores or openings were occasionally left around the wall and supporting

pillars where the sand and cement had not entirely filled these openings between the gravel. The termites had come through these openings then had built their mud tunnels up the walls and concrete pillars, worked into the wood shelves then had destroyed many sets of older periodicals which were stored here temporarily. An enormous amount of labor, extra construction, new shelves and replacement of many sets of periodicals have been necessary. This specific example is typical of many similar infestations and losses which could be cited.

If these pests could be easily controlled the problem would not be so serious, but economic control is difficult to accomplish after they are once established and they frequently become established in the modern home as previously indicated. The superheating process in an infested house seems to be the only sure method and this is very hard to accomplish in most buildings because of lack of sufficient heating equipment to raise the temperature to the necessary degree without danger of fire. Fumigation with cyanide and other gases is not successful in many cases since it seems to be impossible to penetrate these inside burrows with gas until after the emergence holes have been made in the wood. Therefore the termite infestation in the house of modern construction still is a problem although the degree of damage has been reduced.

BOOK REVIEW.

THOMAS SAY, EARLY AMERICAN NATURALIST. By Harry B. Weiss and Grace M. Ziegler. Published by Chas. C. Thomas, Springfield, Ill., 1931.

We have in this volume a most welcome addition to the literature on early American Entomology as the authors have succeeded in bringing together a very interesting collection of incidents concerning the life of this famous naturalist, much of it hitherto inaccessible or unknown to the entomological fraternity. The book includes a sketch of what could be learned about the Say family, accounts of Say's various travels and explorations and copies of his letters to friends, especially to the Melsheimer's, on entomological matters. There is also a vivid picture of his connection with the community at New Harmony, Indiana, of which he was a part. The illustrations include, beside two portraits of Say, those of Mrs. Say, McClure and LeSeuer, and reproductions of letters, scenes in Philidelphia, New Harmony, etc.

H. O.

HIVE TEMPERATURES FOR EACH HOUR OF A DAY.*

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INTRODUCTION.

Of the climatic factors in the environment of the honey-bee, temperature modifies their reactions more than any other factor. The well known clustering of bees during the winter and the period of normal brooding of honeybees are two distinct physiological conditions within the colony, brought about by the one environmental factor, temperature. The former condition has been the subject of a great deal of experimental work and has been worked out rather thoroughly. On the other hand, investigations on the latter condition have been more or less limited.

This study on the temperatures within the colony was carried on during the summer of 1926.

I wish to express my appreciation to Professor W. M. Barrows for his helpful suggestions and encouragement in many phases of the work; to Dr. E. F. Phillips, Cornell University, for loaning German beekeeping literature pertaining to hive temperatures, and to Mr. Morris Schlosberg, for his help in constructing the compound thermocouple.

REVIEW OF IMPORTANT PAPERS ON HIVE TEMPERATURES DURING SUMMER.

Francis Huber (1791) who was one of the early investigators on bee life, made observations on brooding temperatures. He stated that in hives rearing brood during the month of January he had obtained the temperature of 93 degrees F. He criticized the statement of Dubost, of Bourg-en-Bresse, that larvae could not hatch below 104 degrees F. Huber stated that the ordinary temperature of hives in summer was from 95 degrees to 97 degrees F. One particular observation was made when the outside temperature was 94 degrees F. At the same time in the most populous hive it did not rise above 99 degrees F.

*Contribution from the Department of Zoology and Entomology, Ohio State University, No. 107.

A. I. Root in 1899 made some observations on the proper temperature for brood rearing. He placed a self-registering thermometer in the center of the brood nest of a medium sized colony and found that the coolest temperature reached during the night period when the external temperature was below freezing was 92 degrees F. In stronger colonies he observed that the temperature registered 95 degrees F. on very cool nights. During a very hot day in August when the external temperature registered from 90 degrees to 95 degrees, he found that in a strong colony the highest point reached was 98 degrees F. In conclusion he stated that the temperatures most conducive for successful brood rearing within the hive were between 92 degrees and 98 degrees F.

Gates in 1914 carried on extensive studies on the temperature within the bee colony during the winter and summer periods. Gates reported some observations which were made in 1908. On March 12th, he opened a hive and found eggs less than 3 days old. At a corresponding time, the course of thermometer c, which was in the region of egg laying, changed; and the inverse relationship which existed during the winter period was no longer apparent. He stated that the trend of the thermometer c was slightly upward during the warmth of the day which corresponded somewhat with the warmth of the outside temperatures. He said that there was a transition from winter to summer (a broodless condition to a condition of normal brood rearing) covering a period of two weeks. In the middle of the brood nest during the summer period, there was no appreciable correlation between the brood temperatures and external temperatures. The hive temperature as a whole was independent of external temperatures, however, a few exceptions to this occurred. The temperature in the brood nest was remarkably constant, ranging from 93.2 degrees to 95 degrees F. The range of the oscillation showed the consistency of the temperature during the height of the season and the greater fluctuations in the spring and fall.

Brunnich in 1919 conducted some research work on colonies rearing brood. All of his observations were taken on weak colonies. Of 27 brood nest readings the temperature was 113.36 degrees F.; 17 were 104 degrees F.; and 7 were 105.4 degrees F. He said that brood did not tend to cool off the hive, but rather was a heat producer which could exist only in an environment

of about 98.6 degrees F. He stated that his observations were probably more or less inaccurate.

Armbruster in 1923 published an article on the temperatures within the bee colony. This work summarized the observations carried on by Lammert in 1894 and 1895 and those of Gates in 1914. He referred to Lammert's notes concerning a swarm of bees hived in a burlap sack within which a temperature of 100.4 degrees F. was obtained. After 8 days, the time when a first swarm possesses a good brood nest, normal temperatures of 95 degrees were resumed. Armbruster continued to describe Lammert's work, but in conclusion he stated that this work agreed with Gates' observations in almost every case with the exception that Lammert's temperatures were somewhat higher of the two. Armbruster commented on the few tables presented by Gates and explained that these tables became much more fruitful when arranged in graphic form. In brief, Armbruster believed that the brood nest temperatures never go below 93.2 degrees F. and seldom above 95 degrees F. He said that when the low level of 93.2 degrees F. occurred there was a direct response of the bees to prevent the temperature from becoming any lower; and that when the temperature reached 95 degrees F. there was a direct cooling off response by the bees so that temperatures would not rise above that point.

Hess in 1926 carried on some extensive experiments on the temperature of a colony of bees during winter and summer. He said that inside the brooding sphere 95 degrees to 96.8 degrees F. prevailed whenever extraordinary outside temperatures did not hold sway. He found a variation of only .36 degrees to .76 degrees F. during the course of a day, even though the outside temperature might cover a wide range of variation. He stated that the mechanical regulation of temperatures in bees is as steady as in humans; that is, they have an effective regulation toward low and high external temperatures. On a day in August, when the maximum outdoor temperature was 93.2 degrees F. he placed an electrically heated pad under a colony of bees and obtained a temperature over the honey comb of 104 degrees F., in the broodless region of 100.76 degrees F. and in the sphere of brooding of 96.8 degrees F. Hess thought that only the evaporation of water was effective in lowering the temperature in the brood area.

Milum in 1928 reported some of his observations. He said that apparently 91 degrees to 92 degrees F. were necessary to

stimulate the beginning of brood rearing, but that this temperature did not need to be maintained for the continuation of brood rearing. Temperatures as low as 76.3 degrees F. were observed with no apparent ill effects on the brood except that it retarded development. During the spring period, temperatures of 85 degrees F. in the brood nest were not uncommon. When brood rearing had become well established in late spring and summer, the brood area ranged from 90 degrees to 95 degrees F. The highest temperature recorded by Milum was 98.2 degrees F. Temperatures above 95 degrees F. tended to cause the bees to hang outside the hive.

Vansell reported in 1930 a temperature of 108 degrees F. in the brood nest when external temperatures reached 116 degrees F.

CONDITIONS UNDER WHICH THE EXPERIMENT WAS CONDUCTED.

This experiment was performed on the roof of the third floor of the Botany and Zoology Building of Ohio State University, Columbus, Ohio. This place was selected because it was a convenient location, the space was well adapted for an experiment of this nature, and moreover the experiment would be less disturbed here than in any other available place. The colony used in this experiment was of the Italian race of bees.

On June 18th, 1926, the colony in a ten frame standard hive was taken from the college apiary and placed on the roof of the third story near the place where the experiment was to be carried out. On June 30th, two and one-half pounds of young bees were added to the colony so that the total number of bees was 35,000–45,000.

After the colony had become adjusted to this location, it was set back on a platform within the building so it was on the same level as the bottom of a window casing. The lower half of the window was raised and the open space covered with beaver board. The entrance of the colony was extended out of doors by means of a tunnel 14½″ x 8″ x ⅞″. The outdoor entrance to this tunnel measured 4½″ x ⅜″.

Temperatures within the colony were taken by means of the electrical thermocouple method, but room and outdoor temperatures were taken with mercuric thermometers. The general set up of the compound thermocouple was similar to that outlined by Robinson in the Journal of Economic Entomology, 1927.

Each thermocouple junction was checked for accuracy against a tested mercuric thermometer covering the range of degrees in temperature that might possibly be involved in the experiment. There were eight thermocouple wires running into the hive at various locations, but all were placed at the same depth which was 4½ inches from the top of the hive. The ends of the wire at the thermocouple junction were placed in a thin glass tube, the end of which was closed. To prevent air currents, tape was wound around the open end of the glass tube and also at the place where the glass tubes pass through the inner cover of the hive. The reason for placing the thermocouple junctions in glass tubing was that we desired only representative temperatures of the region in which the thermocouple was located. The glass tubing tended toward avoiding any local influence such as a bee fanning its wings vigorously near the exposed junction, or the placing of propolis on the junction.

HIVE TEMPERATURES FOR THE DAY.

Two days after taking the hourly temperatures of the colony, it was examined and notes were taken on the exact position of the brood, the honey, and the empty comb space. The temperatures occurring within the hive were divided into three distinct classes; those occurring in the central brood area, in the outer brood area, and in the broodless area. Table I gives the temperatures occurring hourly during the experiment. Figure 1 gives a graphic representation of the temperatures prevailing hourly in the different regions within the colony. The two curves designated as room temperature and outdoor temperature represent the external temperature to which the colony was exposed during each hour of the day.

As shown by the curves, the influence of the environmental temperatures has very little, if any, influence on the temperatures of the central brood area. This is shown clearly as the difference between the maximum and minimum temperatures, 94.1 degrees F. and 93 degrees F. respectively, was only 1.1 degrees during the entire twenty-four hour period. This demonstrates the proficiency of the ability of the bees to maintain a very constant temperature in the central brood area when the external temperature is similar to that represented by the graph. It would seem then when comparing the central brood area temperatures with the curves rep-

TABLE I.

HIVE TEMPERATURES FOR EACH HOUR OF THE DAY.

July 28, 1926	Av. Temp. Central Brood Area	Av. Temp. Outer Brood Area	Av. Temp. Brood-less Area	Room Temper-ature	Outdoor Temper-ature
8:00 A. M.	94.1° F.	87.7° F.	85.2° F.	78° F.	68° F.
9:00	93.5	87.5	83.2	78	70
10:00	92.8	86.7	82.2	80	76
11:00	93.5	87.2	82.2	80	82
12:00	93.2	87.2	81.7	82	86
1:00 P. M.	92.6	87.5	84.5	84	90
2:00	93	89	85.7	85	100
3:00	93.2	90	87.2	86	104
4:00	94	91	88.5	88	106
5:00	93.7	92.2	90	88	108
6:00	94	92.7	91.2	88	100
7:00	93.7	93	91.5	88	90
8:00	93.4	92	91.2	87	82
9:00	93.5	91.7	90.7	86	78
10:00	93.4	91.7	90.7	82	76
11:00	93.5	91.2	89.5	82	76
12:00	93.5	90.7	89	82	76
1:00 A. M.	93.5	90.5	88.9	82	73
2:00	93.5	89.7	88.2	82	72
3:00	93.6	90	87.7	81	72
4:00	93	89.5	87.7	81	72
5:00	93.2	89	87.5	81	70
6:00	92.8	88.7	86.7	81	70
7:00	93	88.5	86.5	81	72

resenting external environmental temperatures that there was only a slight, if any, correlation between the temperatures occurring in the central brood area and external temperatures.

The curve representing the hourly temperatures in the outer brood area is extremely interesting as it shows that the tem-

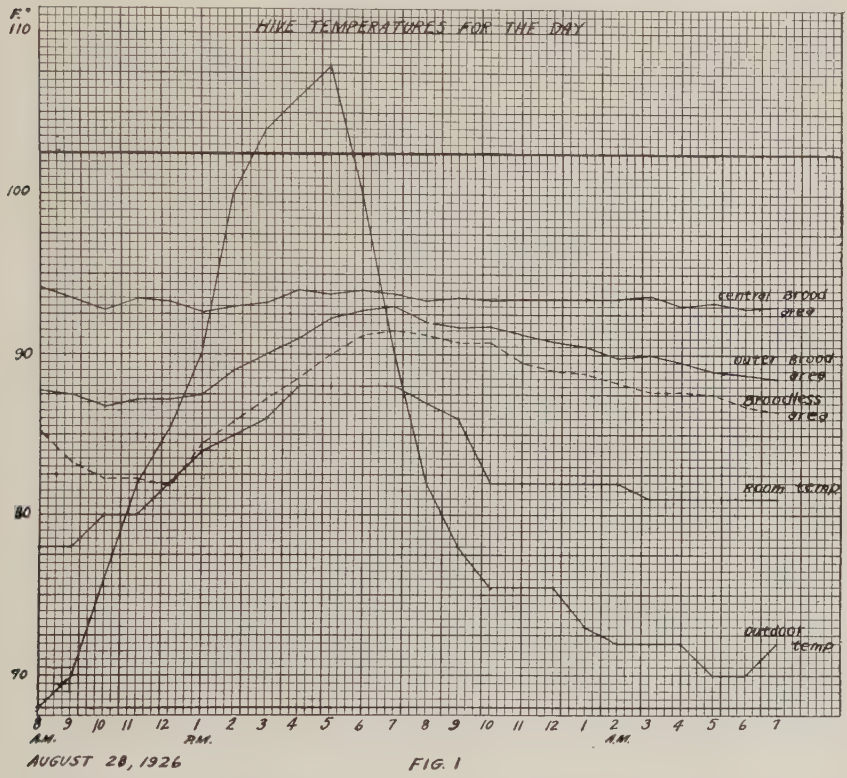

FIG. 1

peratures in this region are quite distinct from those occurring in the central brood area. The temperatures of the outer brood area most nearly approach those of the central brood area when the environmental temperatures to which the colony is subjected reach their highest level. With the gradual lowering of the external temperatures, as indicated in the graph, there is a greater deviation between these two curves. Stating this more directly when comparing the curve of the outer brood area with the curves representing the environmental temperatures, the temperature fluctuates to a certain extent with the rise and fall of external temperatures, such as occurred in this experiment.

The temperatures recorded hourly in the broodless area are the lowest of any region of the hive and when comparing this curve with the environmental temperature curves, it seems to be influenced to the greatest extent.

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THE HYPSOMETRIC MAP VERSUS THE PROJECTED PROFILE METHOD IN PROTRAYING AND DETERMINING EROSION SURFACES.

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In the past, two methods have been used to determine erosion levels, the hypsometric and profile methods. The question arises as to which is the better. In the hypsometric plan the erosion surfaces are determined by coloring in, on a topographic map, all the points at a definite elevation or approximately that. Various colors are used to differentiate the levels. The disadvantages of using the hypsometric method are many. A peneplane or erosion surface is not a level one, but rolling, rising toward the divides and descending toward the streams and their outlets. Even in the penultimate stage of the cycle of erosion, a peneplane would vary considerably in elevation; in the case of the Schooley (Kittatinny) surface in eastern Pennsylvania, a difference of more than 300 feet. To attempt to color in an undulating, peneplaned surface, varying several hundred feet in elevation seems impossible. The danger lies in getting too many erosion surfaces. The point is, that one undulating, peneplaned surface might easily be misinterpreted as several.

In the determination of any peneplane surface it is necessary to consider the hardness of the rock, the composition of the rock, distance from major streams, width of rock outcrop, thickness of the formation and temporary base levels. These factors, even in the penultimate stage of the cycle of erosion, should be considered. Sloping surfaces on a peneplane do not show up on a hypsometric map. Furthermore, it is very difficult, if not impossible, to picture in one's mind's eye the topography as colored in on a series of contour maps. Another serious objection to the hypsometric map is that when it is completed, even though it covers a comparatively small area, it is too large to be published. When a considerable area is reduced to a size suitable for publication, much of the detail must necessarily be eliminated. It is difficult to gain a proper conception of a peneplane or erosion surface by means of a hypsometric map.

One of the first to use projected profiles in determining erosion levels was Joseph Barrell[1]. More recently, Douglas Johnson of Columbia, Frank Wright of Dennison and the author have used projected profiles in connection with their work in the Appalachian region. In this method, the area to be projected is outlined on the topographic map. The topography is systematically projected onto cross-section paper with the aid of a T-square. Ordinarily the highest points in any belt of definite width are plotted and a line connecting them gives the profile. The narrower the belt projected, the more accurate the results and the broader the area projected the greater the amount of concealed lowland. Where one wishes to construct profiles of erosion surfaces it is more desirable to have a projection of the entire area than of a limited area, only that covered by the lines along which linear profiles are made.

The major disadvantage of the projected profile is that some of the lower points are concealed by the higher areas. But this can be eliminated to a large degree by projecting a narrower area. Upon the completion of the profiles on cross-section paper they can be transferred to heavy cardboard. It is then possible to cut them out and by means of supports they can be placed in the proper position to be photographed.

A modification of the projected profile method has been used by Miss Cornish[2]. The projected profiles were transferred to glass. The resulting transparencies were then assembled in exact register and viewed by transmitted light. This method provides a test by which it may be determined whether the hidden, lower elevations invalidate any determination based on results obtained by the regular projected profile method. The only difficulty here is that in case of a large number of profiles the result appears to be a confusion of intersecting lines, difficult to interpret. Furthermore, this method does not give perspective, the effect of depth as well as height and breadth. On the whole, the regular projected profile method, in the opinion of the writer, is superior to any yet devised to depict erosion surfaces.

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[1]Barrell, Joseph. "The Piedmont Terraces of the Northern Appalachians," *American Journal of Science*, 4th series, Vol. 49, 1920.

[2]*Journal of Geology*, Vol. 37, No. 2, p. 117.

OBITUARY.

PHILIP ROSEMOND LOWRY, M. Sc.

Philip Rosemond Lowry, B. Sc., Ohio State University, of 1920, died at Durham, New Hampshire, April 29, 1931.

From accounts received at the University it appears that he suffered a heart attack and his death was sudden and unexpected. "Phil" Lowry was an outstanding student while in the University, a great favorite with teachers and associates, combining a virile activity and brilliant intellect with a delightful personality which resulted in many friendships. In his chosen work in entomology he showed great promise and after taking his Master's degree in 1921 he received an appointment in the University of New Hampshire under Professor W. C. O'Kane (class '97). In this position he had been rapidly advanced in the work of the department and was at the time of his death ranked as Assistant Professor.

He was a member of the American Association for the advancement of Science, the American Association of Economic Entomologists, the Entomological Society of America, the Ecological Society of America, the Ohio Academy of Science and other scientific societies.

He was born September 24, 1896 and his death in his 35th year on what seems the threshold of a brilliant career in science is a heavy blow to a host of admiring friends and associates.

—Herbert Osborn.

BOOK REVIEWS.

DEMONS OF THE DUST. By WILLIAM MORTON WHEELER. W. W. Norton & Company, Inc., Publishers, New York.

Doctor Wheeler has brought together under this rather striking title a very interesting collection of studies upon certain groups of insects which have developed very striking habits in securing their food.

There is an interesting chapter on "Some Eighteenth Century Naturalists," treating of certain writers who presented the results of their studies of these insects; a chapter on "The Fauna of the Sands," giving a general survey of adaptation to arid conditions, then a series of chapters reviewing studies of different dust or sand inhabiting species with a quite complete monograph of the genus *Lampromyia*. Appendices include translations of early papers by De Geer and Réaumur. There is an extended and very complete bibliography.

The book is written in Doctor Wheeler's very interesting style and the illustrations and descriptions are evidently of his usual exact and illuminating character. The book will appeal to a wide circle of readers, both on account of its entertaining style and the remarkable habits of the insects treated.

REPORT ON THE GAME SURVEY OF THE NORTH CENTRAL STATES. By ALDO LEOPOLD. For the Sporting Arms and Ammunition Manufacturers' Institute Under the Direction of its Committee on Restoration and Protection of Game.

This exhaustive report, while intended especially for those interested in game protection, includes many features that will be of interest to conservationists, especially to those interested in the preservation of wild life in as nearly as possible native conditions.

It includes surveys of the central northern states, Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, Iowa and Missouri and treats of the principal game birds and animals, many of them being species which are in danger of serious reduction or extermination. It includes numerous maps and charts and tabulated results of field studies. Copies are obtainable from American Game Association, Investment Bldg., Fifteenth and K Streets, Washington, D. C., at $1.00 each, postpaid.

EXPERIMENTS IN ATOMIC SCIENCE FOR THE AMATEUR. By JAMES L. CLIFFORD. Published by Richard G. Badger, Boston, Mass.

This work is intended to give simple directions for the performance of experiments by amateurs and deals particularly with radio active substances, atomic structure, electrons, osmosis and ultra violet light. A brief bibliography is included.

H. O.